POWER

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The Value of the Exhaust

IT TAKES 1,322 B.t.u. to convert a pound of water from about 79 degrees, the temperature of steam at 29-in. vacuum, into a pound of steam at 300 pounds absolute, superheated 300 degrees.

An ideal engine or turbine working this steam from its superheated condition and 300 pounds down to the 29-inch vacuum could convert only about 468, or 35.4 per cent, of the 1,322 B.t.u. furnished by the boiler, supposing the steam to be made from the 79-degree condensate, into work including that required to overcome its own resistances.

Almost 65 per cent of the heat supplied by the boiler would be voided to the condenser and discharged into the river.

This for an ideally perfect engine. If it had a conversion efficiency of 75 per cent, only 351, or 26.6 per cent of the 1,322 B.t.u. furnished, would be recovered and 73.4 per cent be discharged to the river.

If this ideally perfect engine worked the 300-pound superheated steam down to atmosphere pressure instead of to a 29-inch vacuum, it could convert only about 272, or 22.9 per cent of the 1,189 B.t.u. required to make a pound of steam from water at 212 degrees corresponding to the pressure of the exhaust. If the engine had an efficiency of 75 per cent instead of being ideally perfect, thermodynamically, it would convert only 204 B.t.u., or about 17 per cent, and 83 per cent of the heat furnished by the boiler would go out in the exhaust.

But this exhaust has a temperature of 212 degrees and may be used for heating, drying and manufacturing processes. It is ordinarily as good for these uses as steam made on purpose.

If it could all be condensed, by doing heating and useful work, back to water at 212 degrees where the boiler started with it, all the heat put into it by the fuel would be either converted into power or absorbed in some process for which, otherwise, additional fuel would have to be burned.

If a pressure greater than that of the atmosphere is required, the engine or turbine can be run against that back pressure.

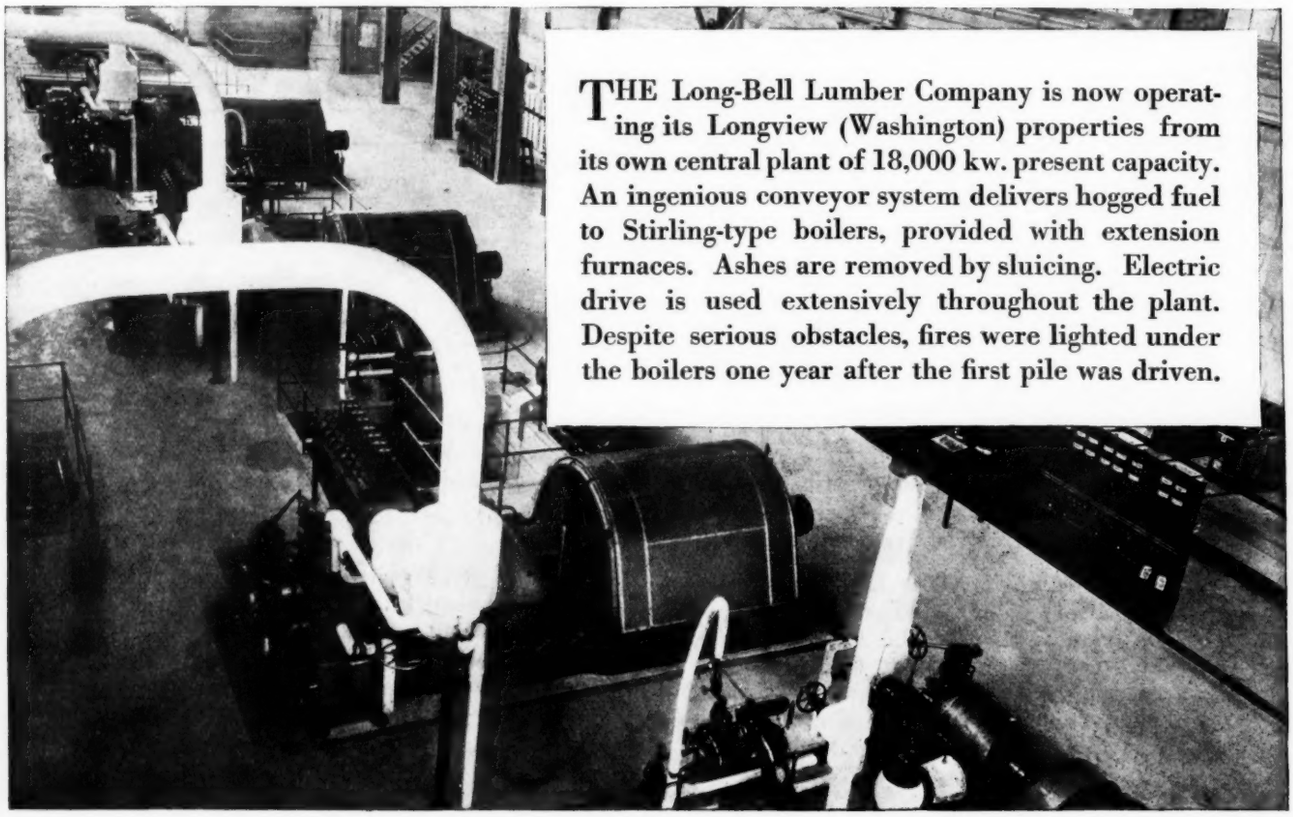
It will take more steam per horsepower or kilowatt-hour, but what does it matter? All the heat that it does not convert into power goes out in its exhaust, and if the exhaust could all be used to advantage, it would make a 100 per cent instead of a 25 per cent arrangement.

Of course, it rarely if ever occurs that the demand for steam for heating and process work synchronizes with that for power, but where any considerable demand exists for heat that can be supplied by comparatively low-pressure steam, that demand furnishes an opportunity for obtaining whatever power can be generated by the required amount of steam in falling from a higher to the required pressure.

It takes 1,150 B.t.u. to make a pound of steam at atmospheric pressure, and it takes only 54 B.t.u. more to make it at a pressure of 300 pounds.

F. R. Low

18,000-Kw. Plant Serves Lumber Company



THE Long-Bell Lumber Company is now operating its Longview (Washington) properties from its own central plant of 18,000 kw. present capacity. An ingenious conveyor system delivers hogged fuel to Stirling-type boilers, provided with extension furnaces. Ashes are removed by sluicing. Electric drive is used extensively throughout the plant. Despite serious obstacles, fires were lighted under the boilers one year after the first pile was driven.

WHEN IT IS considered that the average large saw mill in the Pacific Northwest does not require more than 3,000 kw. of generating capacity, it becomes evident that the new power plant of the Long-Bell Lumber Co., with a present rating of 18,000 kw., is noteworthy. Even this is only a beginning; provision has been made for an ultimate capacity of 36,000 kw., of which 24,000 can be generated in the present building by the addition of a fourth 6,000-kw. generator.

Other interesting features of this plant are: a special belt-conveying system for handling the hog fuel (wood refuse) to the boilers; the construction of the plant on foundations placed below the high-water level and protected by dikes; two reinforced concrete chimneys 21 ft. in diameter (inside) at the top and 300 ft. high; the extensive use of motor-driven auxiliaries and the intake of circulating water through a system of canals and ponds.

The plant, which is located at Longview, Washington, was designed for the Long-Bell Lumber Co. by Charles C. Moore & Co., Engineers & Contractors. Speed was essential as power was required at the earliest possible date for the operation of a new saw mill. This requirement was met, the first fire being lighted under the boilers on June 18, 1924, just one year after the first pile was driven for the foundations.

The use of piling was rendered necessary by the location of the plant and mill site below the high-water level, the site being protected by dikes. Over 3,000 piles, ranging up to 60 ft. in length, were driven, practically all by "jetting," as the only means of getting down to the desired depth. The piling, cut off below the permanent ground-water line, supports the concrete foundations of the buildings and machinery.

As is evident from the accompanying photographs, the power plant is of impressive size for an isolated plant, being 192 ft. wide, 296 ft. long and the equivalent of five stories high. The three permanent walls of the building are constructed of concrete brick and finished on the outside with fire-flashed brick of the same material. Windows and doors are protected by rolling steel shutters. The plant is of fireproof construction, being entirely supported on structural steel and provided with brick curtain walls.

While oil-burning apparatus was provided on four boilers to get the plant into operation at times when there was no supply of other fuel, the fuel for regular operation will be the hogged saw-mill waste, which is handled from the fuel-storage house to the boilers by an elaborate system of conveyors. To transport this from the fuel house to the boiler room, 48-in. troughed belts are used, which in some instances run at rather steep angles. Arriving at the boiler house, the fuel is transferred from the belt conveyors to any one of the four boiler-feed conveyors, of which two supply the boilers in each half of the boiler house. The boiler-feed conveyors consist of cables with cast-steel flights and are operated by means of gap wheels and reduction gears.

In putting such a system into operation it is best to start the conveyors one after another, beginning with the last, in order to reduce the starting load and prevent excess fuel from collecting at any transfer point. At the Long-Bell Lumber Co.'s plant this is accomplished automatically. The pressing of the

Fig. 1—(below) Room containing the oil circuit breakers which handle 18,000 kw. generated at 13,200 volts and 60 cycles

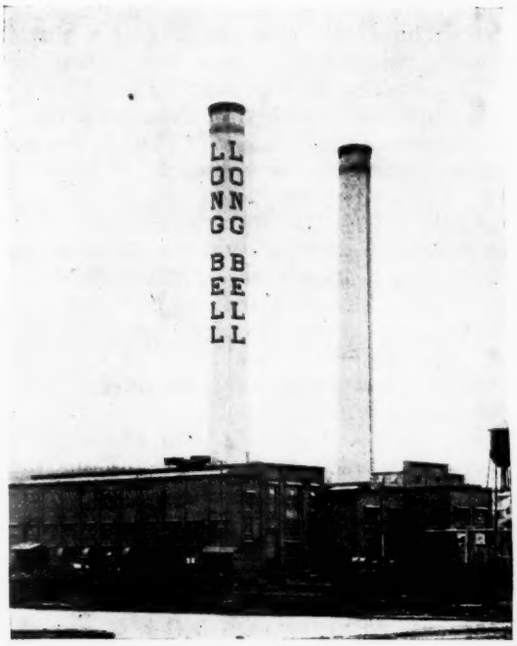
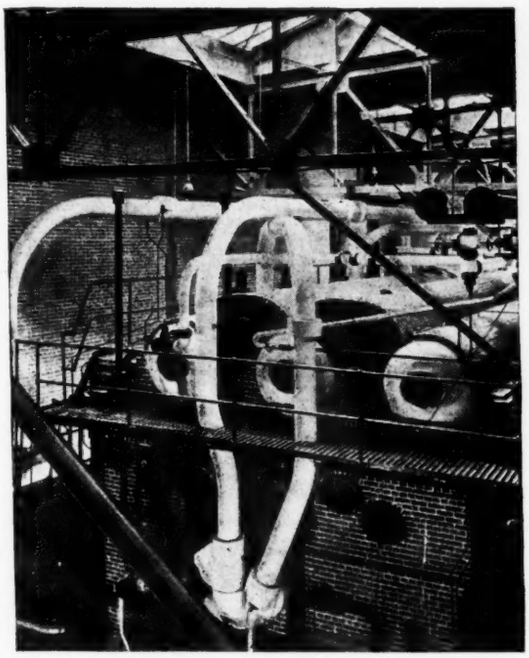


Fig. 2—(above) Exterior of Long-Bell Station. The two 300-ft. concrete chimneys are designed to handle the ultimate capacity of 36,000 kw.

Fig. 3—(below) This photograph shows the top of one of the eight 11,950-sq.ft. Stirling boilers. Extra-large furnaces are installed to burn wood waste



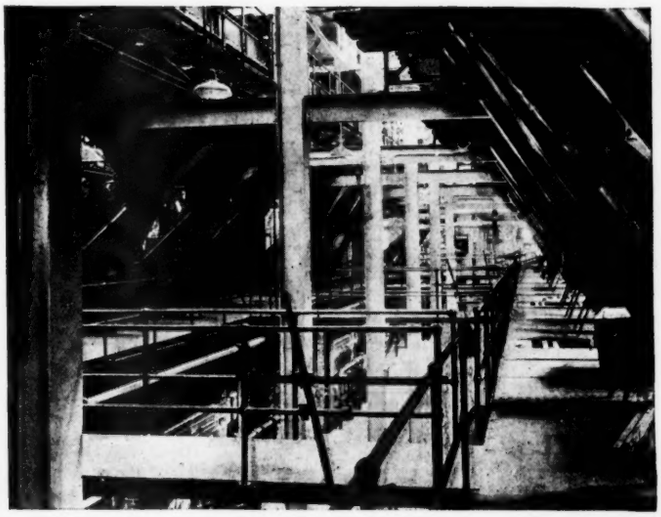


Fig. 4—(above) Hogged fuel, carried first by 48-in. belts and then by scraper conveyors is delivered to the furnaces through the chutes here shown

master-control button throws into operation a series of automatic time relays which, without further assistance from the operator, start the successive motors at the proper intervals. The pressing of a single button shuts down the entire system. The fuel-storage house with its conveying system was installed by the engineering staff of the Long-Bell Lumber Co. Fig. 4 shows the chutes by means of which the conveyors deliver the fuel to the furnaces.

Smoke and Cinders Largely Eliminated

The boilers, Fig. 3, are of the Stirling type with 11,950 sq.ft. of heating surface. They are designed for 250 lb. working pressure and are provided with superheaters to give about 125 deg. superheat at normal rating. For the proper combustion of the hogged fuel large extension furnaces are provided. The boilers operate easily at 200 per cent of rating under reduced draft, but the total capacity with full draft has not yet been determined. In the design of this plant particular stress was laid on the elimination of smoke and cinders. Operation to date has been entirely satisfactory in this respect.

The ash is handled by a sluicing system similar to that already installed in a number of large stations. The large ashpit under each boiler is provided with flooding pipes. A system of sloping concrete trenches leads to two motor-driven specially designed ash pumps. These discharge the material into a concrete ash pump outside the building, from which the ashes are removed by a locomotive crane.

In the present installation 60-cycle current is generated at 13,200 volts by three 6,000-kw. Curtis-type turbo generators.

In connection with the complete lubricating oil systems, consisting of oil tanks, filters, pumps etc., for the turbine bearings, consideration had to be given to the possibility of débris in the water. To allow for this the oil coolers are equipped with extra large tubes. A continuous supply of water to the turbine-bearing oil coolers is insured by a storage tank on the roof of the power plant. This in turn is supplied by special centrifugal pumps. The water discharged from the turbine oil coolers is wasted.

Air for cooling the generators is drawn from the turbine room basement and passed through air washers where it is cleaned and cooled. After passing through the generators the air is conducted to the outside of the building through galvanized iron ducts.

Direct-current motor-generator sets with a storage battery floating on the line furnish control current for the switchboard and power for emergency lighting.

For excitation current there is a motor-generator set, in addition to which is provided a dual-drive exciter.

PRINCIPAL EQUIPMENT OF LONG-BELL LUMBER COMPANY POWER PLANT

GENERAL

Location of plant	Longview, Washington
Character of service	Saw-mill load
Capacity installed, kw.	18,000
Capacity present building, kw.	24,000
Capacity, ultimate, kw.	36,000
Dimensions present plant building, ft.	192 x 296 x 5 stories equivalent height
Type of construction	Concrete and brick on piles

BOILERS, SUPERHEATERS AND FURNACES

Manufacturer	Babcock & Wilcox Co.
Number of boilers	8
Type	Stirling, Class XII-51
Steam-making surface, sq.ft.	11,950
Working pressure, lb. gage	250
Superheat at rating, deg. F	125
Steam temperature, deg. F	531
Superheaters	Babcock & Wilcox Co.
Type	Single U tube convection
Furnaces	Hog fuel, fed through chutes

STACK

Type	Coniform reinforced concrete, with brick lining
Designed by	Chas. C. Moore & Co.
Labor by	Rust Engineering Co.
Diameter at top, inside	21 ft.—0 in.
Height, ft.	300

BOILER-FEED PUMPS

Manufacturer	De Laval Steam Turbine Co.		
Type	Centrifugal		
Number	1	1	1
Size, in.	8 in.	6 in.	8 in.
Capacity, 1000 lb. water per hr.	800	360	800
Drive (turbine or motor)	T	T	M

FEED-WATER HEATERS AND METERS

Heater manufacturer	Cochrane Corp.
Type	Open, with storage tank
Number	2
Normal capacity, lb. per hr.	400,000
Venturi meter, one	Builders Iron Foundry
Capacity, lb. per hr.	1,129,000

MISCELLANEOUS PUMPS

("MDC"—"Motor-driven Centrifugal")

Screen Washing, 2, MDC, 600 gal. per min.	De Laval Steam Turbine Co.
Turbine-bearing water, 2, MDC, 520 gal. per min.	De Laval Steam Turbine Co.
Trans. cooling water, 2, MDC, 50 gal. per min.	Krogh Mfg. Co.
Air washers, 3, 30,000 cu.ft. air per min.	Spray Engineering Co.
Boiler Wash pump, 1, MDC, 500 gal. per min.	De Laval Steam Turbine Co.
Sluice pumps, 2, MDC, 800 gal. per min	Byron Jackson Iron Works
Desuperheater pump, 1, MD Triplex, 35 gal. per min	Goulds Mfg. Co.

WATER-PURIFYING SYSTEM

Sedimentation tank, one 18 ft. dia. x 30 ft. high	Chicago Bridge & Iron Works
Filtered-water storage tank, one 500,000 gal.	Chicago Bridge & Iron Works

FUEL-OIL BURNING EQUIPMENT

Fuel-oil pump, one duplex steam driven	9 in. x 6 in. x 10 in.
Oil heater, one vertical	Griscom-Russell Co.

CONVEYORS

Main and shuttle belts, four 48 in.	P. H. Reardon Co. & Pioneer Rubber Mill
Boiler feed (cable), four 24-in. trough	Various manufacturers
Conveyor drives, 8 motor-driven with speed reducer	Falk Gear Corp.

TURBO-GENERATORS

Type	Curtis Horizontal
Manufacturer	General Electric Co.
Number installed	3
Generators	Three-phase, 60 cycle, 13,200 volts
Capacity, kw. at 80 per cent power factor	6,000
Speed, r.p.m.	1,800
Oil filtration system, Richardson Phoenix	S. F. Bowser & Co., Inc.

CONDENSERS AND AUXILIARIES

Surface condensers, 3, with auxiliaries	Wheeler Condenser & Engineering Co.
Surface, sq.ft.	10,000
Steam-jet air pumps, 3	2-stage with inter and after condensers
Hot-well pumps, 6	3 motor driven, 3 turbine driven
Circulating pump, centrifugal, motor-driven, 3	One 31,000 gal. per min., one 23,000 gal. per min., one 8,000 gal. per min.
Circulating pump, centrifugal, turbine-driven	8,000 gal. per min.
Rex traveling screens, motor-operated, Chain Belt Co.	Three 8-ft. wide x 32-ft., two 6-ft. wide x 32 ft.

MISCELLANEOUS ELECTRICAL EQUIPMENT

Motor-generator sets, two, 300 kw., 275 volt	General Electric Co.
Exciter, one, 200 kw., 125 volt, duplex drive	General Electric Co.
Exciter, one, 200 kw., 125 volt, motor-driven	General Electric Co.
Motor-generator sets, two, 25 kw., 170 volt	General Electric Co.
Switchboard	General Electric Co.
Auxiliary transformers, four, 1,500 kva., 13,860–2200/460 volts	General Electric Co.
Transformer inter-cooler	Wheeler Cond. & Engineering Co.

MISCELLANEOUS MECHANICAL EQUIPMENT

Air compressors, two	Ingersoll-Rand Co.
Traveling crane, one 25-ton	Whiting Corp.
Soot blowers, 48	Diamond Power Specialty Corp.
Boiler feed-regulators, 16 Copes	Northern Equipment Co.
Steam flow meters, 11	Cochrane Corp.

Heat-balance control is accomplished by switching the exciter load from turbine to motor or vice versa.

Direct current for the operation of cranes and other electrical equipment about the yard and saw mill is furnished by two 250-kw. direct-current motor-generator sets. Four 1,500 kva. three-winding transformers (one a spare) furnish power at 2,200 and 440 volts for station auxiliary motors. An auxiliary bus structure of concrete and transite houses the starting and running oil circuit breakers for all 2,200-volt motors. The starting bus in this structure is supplied by a special bank of starting compensators.

One large motor-driven air compressor has been installed. This furnishes compressed air for the saw-mill. Air needed for general power plant service is furnished by a small motor-driven compressor.

Steam exhausting from each of the main units enters a 10,000-sq.ft. surface condenser equipped with a two-stage steam-jet air pump. Unusual difficulties were encountered in getting the circulating water to the station, it being necessary to take water from the Cowlitz River through a canal to the main storage pond, and then through additional canals to the log pond adjacent to the plant.

All of these waterways were dredged, the material being used for diking purposes. Water from the log pond passes through a traveling screen into a concrete intake well from which separate suction lines run to four centrifugal circulating pumps of different capacities. Each of two small pumps is designed for full load on one turbine. One of these pumps is operated by a steam turbine and the other by a motor. The two larger pumps are motor driven and of different capacities. The pumps discharge through a common header which leads to the condensers, the water being finally discharged into a header running over the dike into the Columbia River. A second discharge header will be added when the plant is extended.

How Siphoning Is Prevented

Siphoning of the water back into the plant in case of a broken pipe line is guarded against by a check valve in the discharge line. Multiport check valves and electrically operated gate valves protect each circulating pump, so that any pump may be shut down for inspection and repairs. These check valves are specially constructed for this service.

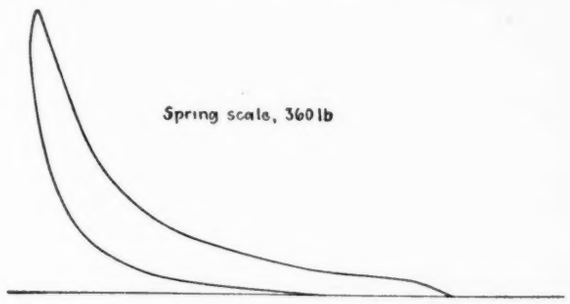
The loose sand and gravel upon which the water screen had to be located in the circulating-water intake presented a difficult problem. The excavation and laying of concrete was carried on under water within a cofferdam of ordinary and sheet piling. After the bottom was sealed the construction was completed inside the cofferdam. For washing the screen, water is drawn from the screen chamber by separate motor-driven pumps at the power plant.

Make-up water is secured from wells adjacent to the plant, the water being treated in a cold-process water softener and filtered through pressure filters. Filtered water is also used for various other purposes about the plant. Feed-water heating is accomplished in two open storage-type heaters, either one of which is large enough for ordinary use. The storage space of the additional heater is used as a reservoir to prevent wastage of water. In the present installation the additional heater will be used for break-down service, but it will be used continuously in the ultimate development of the plant. A large amount of hot water is returned more or less intermittently from the dry kilns of the saw mill. This water is of good quality and high temperature and cannot profitably be wasted to the sewer.

The plant has been in operation since the middle of June. It was completed in ample time to operate the saw mill as required. Expectations as to performance have been more than fulfilled. In design and construction the plant is substantial and complete. Steam-flow meters, draft gages, and thermometers are provided throughout where they will be of service. Access to all the parts of the plant is provided by ample walkways stairways, and platforms.

Indicator Diagrams From Two-Cycle Oil Engine

Engineers who have operated air-injection Diesel engines are familiar with the horizontal or sloping combustion line of an indicator diagram from this engine. On taking charge of solid-injection engines they are inclined to feel an alarm at the peak shown on the indicator diagram. This sharp rise in pressure is a feature of this type engine, being more marked in two-cycle than in four-cycle engines. The oil is injected by a pump at a high velocity and often the entire charge is within the cylinder before ignition occurs. Immediately upon ignition the entire charge undergoes combustion with a marked rise in pressure, as shown in the illustration. The amount of pressure increase depends upon the load conditions and upon the engine design. It is possible at times to reduce the explosion pressure by adjustment of the spray valve spring. This reduces the injection velocity and makes the atomization less perfect and the combustion of the now relatively large oil particles is somewhat slower.



Indicator diagram shows peak

The use of a cup or similar device into which the oil is sprayed and more or less vaporized before introduction into the working cylinder assists in maintaining safe pressures. The oil or gas blows into the cylinder at a lower velocity than when directly injected by a pump. In fact, few if any, two-cycle engines will operate at all satisfactory without such a precombustion device. The reason is probably, the lessened influence exerted by the air temperature which by reason of imperfect scavenging will vary over a wide range under different load conditions. In the four-cycle engine the scavenging is practically the same at all loads, with a more constant end temperature. The design of sprays and the direction of the axis will often produce severe detonations, causing a high peak pressure.

Loading the Boilers to Obtain Maximum Efficiency

By CHARLES E. COLBURN*

ONE of the most vexing of the many power-plant problems of the day is that of obtaining the maximum efficiency from the boiler room. Many boiler-room superintendents are designing and redesigning their stoker grates, clinker pits and wall tuyeres in what is frequently a vain endeavor to secure the maximum efficiency from the equipment under their care.

Boiler manufacturers will give definite guarantees of the expected performance of the boiler and stoker

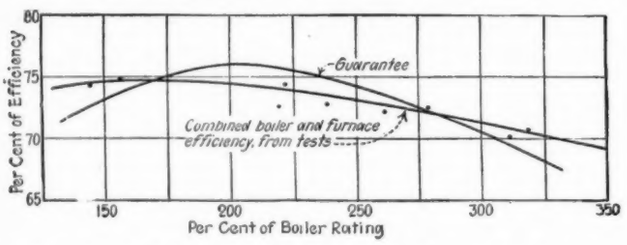


Fig. 1—Builder's guarantees of boiler and furnace efficiency check closely with actual tests

under various loading conditions. In such guarantees it is customary to give curves of the combined boiler and furnace efficiency plotted against the boiler rating as well as the curves of superheat if superheaters are installed, stack temperature, and in a few cases the loss in draft from the furnace to the boiler outlet, all being plotted against the boiler rating.

These guarantees are based upon past performances of similar installations or upon calculations for the present installation with previous performances for their groundwork, and are usually conservative. Power-plant operators are finding it relatively safe to rely on these figures as a measure of the possibilities of their boilers, and but few of the later tests, as carefully conducted by an experienced organization, have failed to meet the guarantees or come near enough to them to be acceptable.

The curves in Fig. 1 show how, in one instance, the test organization of a large power company confirmed the manufacturer's guarantees on a large water-tube boiler equipped with a duplex, clinker-grinding type stoker. The close agreement of the points on the individual tests as found over a considerable period speaks well for the care with which these were conducted and makes their acceptance appear logical. These boilers were designed and built in 1919 or shortly afterward, and the manufacturer's curves as given seem to be characteristic of the boilers of that period. Later boilers of a similar type have curves more in the nature of those indicated by the test results here given. These show that at low ratings it is usually possible to obtain higher efficiencies.

With this fact in mind it can be readily seen that it is wise to divide the load among the operating boilers so that each is at its best point. That means, in boilers of the same type and size that the load be divided equally among the boilers in service. When the boilers are of different types, a little more study will be necessary in order properly to determine the load division and regulate the number and types of boilers in service. However, in the case of the boiler guarantees as made in Fig. 1, it can be shown arithmetically that if the flow-meter readings corresponding to the boiler ratings are 140, 160 and 200 per cent rating, it is more economical to carry the load divided at 167 per cent rating per boiler, when only three boilers are on the line, than to load the boilers in any other way.

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Efficiencies of Boiler Groups

When a number of different type boilers are available and it is desired to bring them on the line one at a time so as to carry the load at the highest efficiency, a study should be made, based upon the manufacturer's guarantees. Tests of the total boiler-room efficiency with the different combinations in service, properly dividing the load among them, are preferred, when possible.

In such studies it is of course expected that those boilers which together are the more economical at the lower load ranges should be considered as being put in service first. The loading curve for a small plant is shown in Fig. 3. From reference to this it will be noted that from single boiler loads of 38,000 to 112,000 lb. steam per hour it will be advisable to carry one boiler on

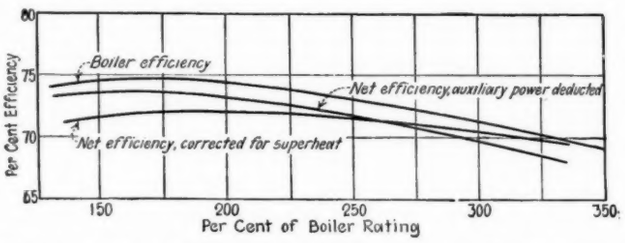


Fig. 2—Boiler efficiency corrected for auxiliary power and effect of superheat on turbines

the line. At 112,000 lb. it will be advisable to bring another boiler on the line and equalize the load, if the efficiency is still to remain at its best.

The loss in each case is shown by continuing the efficiency-load line past the meeting point. In a similar manner it can be seen how the different boilers should be cut in on the line and when, as the steam demand on the boiler room increases. It is an easy matter when the guarantees are known to plot up such a curve for a set of boilers. The boiler-room efficiency can be greatly improved, in the majority of cases, by their use.

However, there is more than the boiler-room efficiency to consider when doing this work with superheater equipped boilers, due to the superheat variations resulting from load changes on the boilers and to the effect of this changed superheat on the turbine economy. In Fig. 2 are shown the curves of Fig. 1 corrected for requirements of auxiliary power and the effect of superheat upon the turbine economy. The curves in Fig. 3 show the boiler-room loading and boiler combinations

that will give the best plant efficiency for any given load, taking the effect of auxiliary power and superheat into consideration. As is evident, it pays to sacrifice a little on the boiler-room economy for the sake of a greater saving in the turbine room.

In these curves it will be noted that the boilers are seldom carried to what are now considered high ratings (over 250 per cent). It is the experience of many boiler operators where there is no attempt to manipulate the boiler loadings, that by carrying more boilers on the line and hence, individual boilers at lower ratings, a more favorable fire can be maintained. In the writer's opinion the one thing that is essential for obtaining high efficiency in the boiler room is comparatively low ratings. Only under such conditions can the stokers be controlled in such a manner as to maintain an even fire, while also keeping good ash conditions and a fair percentage of CO_2. When it is desired to force a boiler, the fire may be controlled for a time, but the CO_2 goes up eventually, and with it furnace temperature, and then the trouble begins.

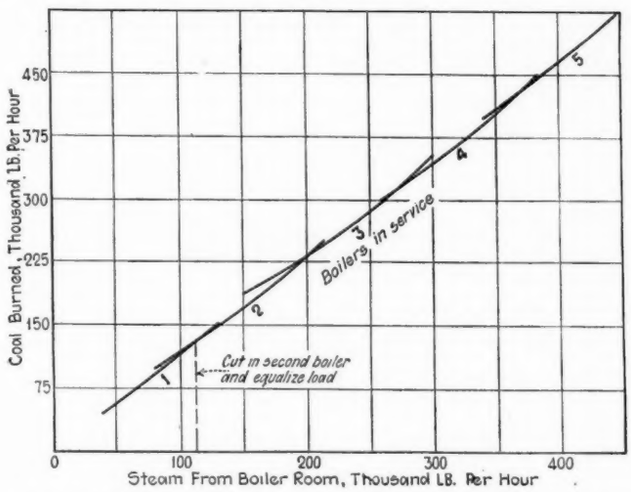


Fig. 3—Fuel requirements indicate the boilers to use for a given output

Boiler efficiencies are corrected for effect of superheat on turbine economy

Since the keeping of records by one of the larger power companies of fireroom results the trend indicates that when low ratings—that is, around 200 per cent—are carried, it is possible to obtain better ash conditions. Lower combustible in the refuse occurs when the CO_2 is kept slightly less, in this case around 12 per cent. Figures of combustible in the ash under 25 per cent are obtained consistently on the boilers with duplex stokers, whose size is around 14,000 sq.ft. It is also their experience, as shown by these records, that when the CO_2 is raised, the combined boiler and furnace efficiency nearly always drops, owing to the fact that the ash combustible loss considerably more than offsets the increased gain from the CO_2.

Many have thought that when the percentage of carbon dioxide was highest, the boiler was doing its best, but a little calculation will show that this is not always the case. In firing boilers, all losses fall into two classes, controllable and uncontrollable. Under the losses which cannot be helped may be grouped those from hydrogen and moisture in the coal and air supplied for combustion, radiation as well as other losses usually estimated into a heat balance as unaccounted for. To a certain degree also, the stack loss is uncontrollable as it is due to stack temperature. The controllable losses include that due to combustible in the ash, the loss due to the formation of CO, and that due to the dry stack gases as affected by the excess air in them.

By assuming some constant stack temperature and ashpit loss, it is possible to calculate and plot a curve showing the effect of CO_2 alone on the boiler efficiency. This assumption of constant stack temperature and ash loss will make a comparison between CO_2 values which is not affected by the different boiler conditions and hence is directly governed by firing.

These figures may be used with varying ash contents and another curve constructed showing the effect of ashpit losses upon the boiler efficiency, this being corrected for the effect of the changed ash condition upon the stack loss. The two curves will enable the controllable losses to be determined for any value of CO_2 and ashpit combustible. It is the sum of these controllable losses that shows what the fireman is really doing and how he is doing it. Of course, for this sort of calculation it is necessary that there be methods of obtaining reliable values for the two losses.

By properly dividing the load among the boilers in service and by strict attention to keeping the controllable losses at their lowest, the boiler load may always be maintained at its reasonably highest efficiency.

Non-Corrosive Turbine Blading Materials

Anti-corrosive materials as used by the Westinghouse company are given in Table I and by the Allis-Chalmers company in Table II, as reported at the World's Power Conference.

TABLE I—LOW-CARBON FORM OF STAINLESS STEEL

	Per Cent			
Carbon	0.07	to 0.12	Proportional elastic limit	60,000 lb.
Manganese	0.80	maximum		
Phosphorus	0.03	maximum	Ultimate tensile strength	90,000 lb.
Sulphur	0.03	maximum		
Silicon	0.25	maximum	Elongation	20 per cent in 2 in.
Chromium	11.50	to 13.00	Reduction of area	60 per cent
Nickel	0.60	maximum	Izod impact	50 ft.-lb.

The heat treatment after forging consists of quenching in oil from 1,750 deg. F., drawing at 1,200 deg. and cooling in oil. In this heat-treated condition the minimum physical characteristics are as given. The present objection to its use is cost.

TABLE II—RUSTLESS NICKEL-CHROMIUM STEEL IN A ROLLED CONDITION

	Per Cent			
Carbon	0.35	to 0.50	Proportional elastic limit	60,000 lb.
Manganese	0.50	to 1.50		
Phosphorus	0.04	to	Yield point	80,000 lb.
Sulphur	0.05	to	Ultimate tensile strength	130,000 lb.
Silicon	0.75	to 1.50		
Nickel	19.00	to 25.00	Elongation	26.0 per cent in 2 in.
Chromium	6.00	to 9.00	Reduction of area	50.0 per cent

This material is quite non-corrosive, but is difficult to work, especially in machining. The cost is high.

Certain companies with advanced methods consider that installations of about 30,000 kw. capacity should not have air leakage in excess of 4 to 6 cu.ft. free air per minute (referred to 70 deg. F.). Regular observations are made and the source of leakage discovered and corrected whenever it reaches a prescribed limit. The 100,000-sq.ft. condenser in four shells serving the 70,000-kw. turbine at the plant of the Interborough Rapid Transit Co., in a test made shortly after installation, showed a leakage of 6.75 cu.ft. per minute.

Locating Faults in Synchronous Motors

By B. A. BRIGGS

Troubles that are liable to develop when starting a synchronous motor are enumerated and then each is discussed in detail and suggestions are made how to locate the faults by the symptoms and by tests.

DIFFICULTIES that may be encountered when starting synchronous motors can be divided into those that develop when the motor is first being put into service and those that develop after the motor has been in satisfactory operation for a period. With the exception of wrong connections the troubles that may develop when the motor is being put into operation for the first time are practically the same as after it has been in operation. In the matter of connections too much emphasis cannot be laid upon the necessity of being sure that they are made correctly. If trouble is experienced in putting a motor into service for the first time, among the first things to be carefully checked are the connections. Unless it is absolutely certain that these are correct, it is of little use to look for trouble elsewhere.

Up to the period of closing the field switch, starting a synchronous motor is similar to starting an induction motor. Therefore, what applies to one type during this period applies to the other. Troubles that can develop during starting a synchronous motor may be classed as: Fails to start; motor starts but fails to come up to speed; motor comes up to near synchronous speed but fails to pull into step when field switch is closed; motor pulls into step but hunts.

Troubles That May Prevent Motor From Starting

Where the motor fails to start when the controller is thrown to the starting position, there are three conditions that may exist: The motor makes no effort to start and does not make a noise; the motor makes no effort to start and makes a buzzing sound; and the motor makes an effort to start, but lacks sufficient torque to move the load.

If the motor fails to start and does not develop a noise, it is a good indication that power is not being supplied to the motor, due either to an open-circuit in the wiring or to the protective devices being open on the feeder circuit.

Where the motor emits a humming sound without making any effort to start, it is an indication of an open-circuit in one phase. A polyphase motor will not start single-phase but will operate single-phase if not too heavily loaded, after being brought up to speed on two- or three-phase operation, depending upon the type of machine. The open-circuit in a phase may be due to the failure of a fuse, poor contact in a switch, open-circuit or poor connections in one phase of the motor's windings or external wiring.

The defective phase can be detected, where no ammeters are in circuit, by opening one of the connections at the motor, as in Fig. 2, and trying to start the machine by closing the starting device. When the live phase has been opened, the buzzing sound should cease when the switch is closed. For example, in Fig. 2 assume that when lead *A* is opened and the switch closed, the motor makes a buzzing noise; this would indicate that the open was in phase *A*. After this has been determined, it is then a case of locating the defect with a test lamp or by inspection.

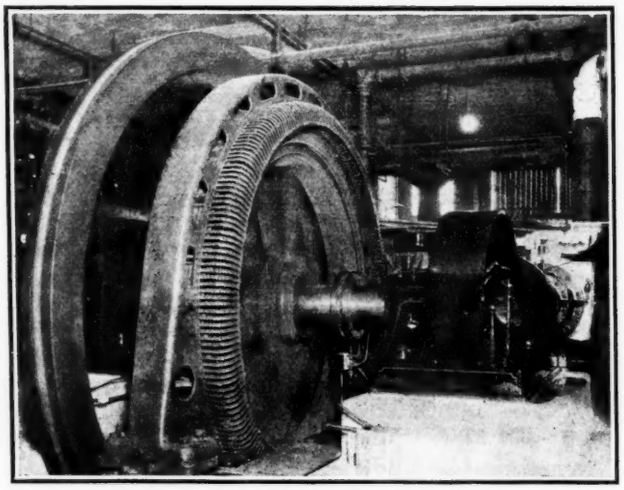


Fig. 1—Direct-connected 600-hp. synchronous motor driving ammonia compressor

If it were found that phase *A* was open-circuited, a test lamp and circuit connected to motor terminals *A* and *B* or *A* and *C*, with the motor disconnected from the line, will indicate whether the trouble is inside the motor or in the outside wiring. If the lamp fails to light, it shows that phase *A* in the motor is open-circuited, whereas if the lamp lights it indicates that phase *A* is complete within the motor, but that the source of the trouble is outside the machine. Although only a switch has been shown in the figure for simplicity's sake, a synchronous motor is generally equipped with some kind of a starting device either in the form of a manually operated compensator or an automatic starter.

Testing for Open Phase

If it had been found that the motor would issue a buzzing sound with either *A* or *B* lead open, this would indicate that all phases were alive and the trouble was not due to an open-circuit. Where all phases are alive, the motor should at least develop a torque that would tend to move the load. However, this need not always be the case, since if for any reason the voltage on the line is very low the motor's torque will be greatly decreased. Since the torque varies as the square of the voltage applied to the motor terminals, if the voltage is reduced to one-half of normal the torque will be reduced to one-quarter that at full voltage. When starting a new motor for the first time, a too low voltage tap may have been selected on the auto-transformers. The remedy for the trouble is to change the connections to higher voltage taps on the auto-transformers in the starting equipment.

Where trouble is being experienced with a synchronous motor failing to start, the voltage of the supply circuit should be checked to see if it is near normal. This check should be made both before and

during the time the motor is connected to the circuit. If the supply lines are too small, they will cause an excessive voltage drop in the line which may cause the motor to fail to start. In such a case it may be of little use to change the taps on the auto-transformers to give a higher voltage at the motor terminals. A higher voltage at the motor terminals will result in an increased current taken from the line, which will increase the voltage drop. The increase in voltage drop in the line may be so great as to offset any gain in voltage at the motor terminals due to changing the tap connections.

In not all cases is an excessive drop in voltage due to conditions on the line. Where the motor represents a large part of the load on the generator, the heavy lagging current taken by the motor during starting may cause a large decrease in the generator's voltage. In this case the attendant at the power house should be called before starting the motor so that he may be on hand to adjust the voltage to normal when the motor is connected to the line.

Another cause of failing to start is short-circuits or grounds in a group of coils in one or more phases. If difficulty is experienced in starting the motor, it is

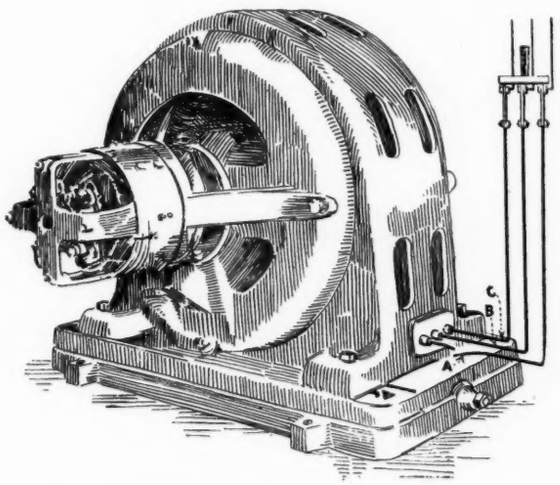


Fig. 2—Testing for open-phase in motor

always a good idea to check the current in each phase as well as the voltage between phases. The current in all phases should be of the same value, as should the voltage between phases. A serious unbalancing of voltage or current should be corrected by removing the cause. Unbalancing of the line voltage if the current taken by the motor is balanced, is due to causes external from the motor and control equipment. Where the line voltage is balanced within two or three per cent, any serious unbalance in the current taken by the motor is due to wrong connections, short-circuits or grounds in the starting equipment or motor. Where an ammeter shows that no current is flowing in any particular phase, it indicates an open in that phase.

When taking current readings with the rotor stationary, the rotor should be turned by hand and the effect noted on the meter. With the rotor standing still and line conditions and connections normal, the current in the different phases will usually differ somewhat owing to the relative positions of the different phase windings and the poles on the rotor. For example, the field poles might be exactly in the magnetic circuit of one phase and only partly in the circuit of the other phases. The first phase would have a greater number of magnetic lines set up about it than about those not so favorably located. The phase in the strongest magnetic field will have the highest counter-electromotive force set up in it and will therefore take the smallest current from the line. Where the rotor is revolved, this condition is continually shifting from one phase to another and the average current in all phases should be substantially the same.

Another cause of failure of a synchronous motor to start is the field switch closed and the coils energized, where the motor is excited from a direct-current power system. Where the motor drives its own exciter, if the field switch is left closed to the exciter a low-resistance circuit is provided for the field coils, which will have a lagging alternating current set up in them of a value that will greatly reduce the starting torque and may prevent the motor from starting. In all cases the field switch should be open, or closed to the discharge resistance during starting. With the field switch closed to the discharge resistance, a short-circuit in this resistance would have practically the same effect as leaving the switch closed to the exciter.

Grounds in Field Coils

Two grounds in the field coils so as to short-circuit a number of the coils would have the same effect as closing the field switch to a low resistance. It sometimes happens that the field coils' insulation is broken down owing to the high voltage induced in these coils by transformer action during starting.

Excessive mechanical load from various causes is not an uncommon cause of motors' being unable to start. Frozen discharge lines on pumps, bypass too small on compressors, or the bypass valve not open, bearings made too tight or seized, or the bearings worn so that the rotor rubs on the stator, may be causes of the motor not starting. All such conditions should be looked into if a motor fails to start. More than one electrician or operator has spent a lot of time looking for electrical cause of a motor's failing to start only to find, or have someone find for him, that the difficulty was mechanical and the motor could not start without wrecking something.

After a motor starts, it may fail to come up to speed owing to the field switch being closed to the exciter or the mechanical load being too great. The latter is liable to be the case on compressors. On air compressors the unloading device may be closed, where on ammonia compressors the bypass may be too small or the valve closed. The heavy flywheel on slow-speed ammonia compressors also makes the motor difficult to accelerate. Poor connection or broken bars in the pole-face squirrel-cage winding may not only prevent the motor from coming up to speed, but may also prevent it from starting.

Single-Phase Operation on Full Voltage

After the motor has been started on reduced voltage and when connected to full voltage, it may slow down again or the circuit breaker may open. This would be an indication of single-phase operation on full voltage, which would be due to an open-circuit in some of the high-voltage wiring or to a poor contact or connection. A very likely cause of such a trouble is a broken or burned contact on the full-voltage switch. Where fuses are used and they are cut out of circuit while starting on low voltage, if one is blown the motor will start,

but when switched to high voltage, single-phase operation will result with the effects previously mentioned.

The most critical period in starting a synchronous motor is bringing it into synchronous speed after the field switch is closed. The motor should come up to within 3 to 5 per cent of synchronous speed before it can pull into step when the field switch is closed. Failure to pull into synchronism may be due to lack of exciter voltage or to an open in the motor's field circuit. If the exciter fails to build up, any of the causes that apply to a direct-current generator are applicable to the exciter, such as an open in the field circuit, brushes not making good contact on commutator or in wrong position, loss of residual magnetism, etc. An open in synchronous motor field circuit may be due to an open in the field coils themselves or in the connecting wiring. Brushes on the slip rings making poor contact, loose or broken connections between the field coils or other parts of the circuit and open-circuits in the field rheostat are other causes of open field circuits.

Where there is an open in the field rheostat, it may be cut out of circuit for one adjustment and cut in for another position of the rheostat's arm. Where the field circuit is closed through the rheostat and the arm moved to a position where the open is cut into circuit, it is generally followed by a severe arc between the contacts where the open is located.

Another cause of the motor's failing to pull into step is short-circuit or grounds in one or more field coils or wrong polarity of field coils. The latter would not be the case with a motor that had been in operation for some time, but could apply to a new motor or one that had been repaired.

Motors Driving Compressors Fail to Pull Into Synchronism

Particularly on slow-speed motors driving compressors, trouble may be experienced in getting the motor to pull into step due to the bypass being too small or the unloading device in the closed position. The heavy flywheels on such machines also make it difficult to accelerate them.

After the motor pulls into step it may develop hunting, that is, have an unstable speed. This is generally accompanied with a humming sound not present during normal operation. This difficulty can be caused by insufficient flywheel weight, other synchronous machines on the system hunting, unstable speed of prime movers driving the alternators or high resistance of a long line connecting the source of power to the motor.

Should hunting develop in a new motor, its flywheel should be checked by a competent engineer, as also the characteristics of the supply circuit. Hunting developing in a motor that has been in service for some time will generally be found due to poor connections in the supply circuit or exciter, unstable speed of prime movers driving the alternators, loose or broken connections in pole-face squirrel-cage winding, or hunting of other synchronous machines on the system. If a motor is running satisfactorily and suddenly develops hunting, it may be due to single-phase operation. Unless the motor is lightly loaded, it should pull out of step and stop on single-phase operation.

Other conditions to be checked are those outlined in the previous article on "Locating Faults in Synchronous Motors," page 456, Sept. 16 issue, which deals with mechanical troubles and the causes of heating.

Operation of Carbon Dioxide Refrigerating Plants

By G. Grow

While practically all refrigerating machines on shipboard, and the majority of such plants in England make use of carbon dioxide, the refrigerating engineers in this country are not so familiar with the details of operation of this type of apparatus as in the case of ammonia systems. As a consequence many engineers are hesitant about assuming charge of a CO_2 plant and even though it may possess advantages over ammonia, for a particular installation, it is by no means uncommon to find engineers discouraging its adoption by reason of their lack of information.

Carbon dioxide is under ordinary temperatures and pressures a colorless gas and in order to liquefy it by water cooling, the gas must be compressed to a very high pressure. The temperature at which the liquid carbon dioxide will boil when under various pressures, which are at the same time the pressures to which the gas must be raised to cause it to liquefy when cooled to the corresponding temperatures, are shown in the accompanying table. It will be noticed that with the condenser cooling water at 70 deg. F. and a difference between the water and the liquid CO_2 of 10 deg., making the latter temperature 80 deg., that the liquid will boil if the pressure is below 965 lb. absolute (950 lb. gage) or the gas will liquefy if the pressure is raised the slightest amount over 950 lb. gage. Inspection also reveals that the evaporating pressure at a temperature of 0 deg. F. is 303 lb. absolute or 288 lb. gage. These temperatures are approximately those found in a plant but the need of a high discharge pressure is apparent. Since a coil temperature of below zero deg. F. is seldom required, the coil pressure need not be much under 300 lb. gage. While lower coil pressures and temperatures could be carried, the power required to operate the compressor depends upon the ratio between discharge and suction pressures and as high a suction pressure as possible should be carried.

PROPERTIES OF SATURATED CARBON DIOXIDE

Pressure Lb. Sq.In. Gage	Temp. Deg. F.	Vol. of Liquid, Cu.Ft.	Vol. of Vapor Cu.Ft.	Heat of Liquid (h)	Heat of Vaporization (L)	Total Heat (H)
130	—40	0.01438	0.609	0	136.3	136.3
159	—30	0.01464	0.495	5.2	132.1	137.3
199	—20	0.01496	0.408	10.4	127.4	137.8
219	—15	0.01514	0.371	13.0	125.1	138.1
241	—10	0.01532	0.337	15.7	122.7	138.4
264	— 5	0.01552	0.308	18.4	120.1	138.5
288	0	0.01570	0.282	21.0	117.5	138.5
314	5	0.01591	0.257	23.8	114.8	138.6
343	10	0.01613	0.234	26.5	112.0	138.5
374	15	0.01637	0.215	29.2	109.0	138.2
406	20	0.01663	0.197	31.9	105.8	137.7
440	25	0.01689	0.180	34.7	102.5	137.2
475	30	0.01718	0.166	37.5	98.9	136.4
513	35	0.01748	0.152	40.5	95.1	135.6
553	40	0.01783	0.140	43.4	91.2	134.6
595	45	0.01820	0.128	46.3	87.3	133.6
638	50	0.01863	0.117	49.3	83.1	132.4
684	55	0.01908	0.107	52.4	78.7	131.1
732	60	0.01953	0.097	55.4	74.1	129.5
782	65	0.02000	0.087	58.4	69.6	127.0
835	70	0.0210	0.078	61.5	63.3	124.8
891	75	0.0223	0.070	64.6	56.5	121.1
950	80	0.0245	0.061	67.6	47.1	114.7
1,014	85	0.0289	0.054	70.7	33	103.7
1,063	88.4	0.049	0.049	72.7	0	72.7

These high pressures introduce problems of compressor design and piping arrangement not encountered in ammonia plants. It has been the practice in the past to equip the compressor with a piston having

leather cups instead of metal rings. This was and is a poor makeshift, for there is no reason why a piston with well made snap rings should not prevent leakage. In fact, as long as the high pressure is more than twice the low pressure, the amount of leakage through a given opening is not changed regardless of how high the high pressure may be. In other words, ammonia and CO_2 will show the same leakage by a piston.

The stuffing box likewise will offer no more troubles than one in an ammonia compressor. However, CO_2 has one disadvantage in that a leakage of ammonia will make itself evident by its smell while carbon dioxide may leak badly and go undetected by reason of the absence of odor.

The lubrication of the carbon-dioxide compressor does not offer the difficult problem encountered with the ammonia machine. In the latter compressor the temperature reached during compression of the ammonia gas may be very high. This high temperature tends to break down many lubricating oils and is in any event high enough to cause evaporation of a considerable percentage of the oil. This should be trapped out by a separator but in practice the oil compresses in the condenser and mixes with the ammonia forming an emulsion or sludge in the evaporating coils. On the other hand the discharge temperature in a CO_2 machine is under 200 deg. F. and the gasification of the lubricant is greatly reduced. In addition, CO_2 does not emulsify with the oil and if any of the latter is carried over to the coils it flows along without the formation of a sludge.

Amount of Lubrication

It is impossible to state the exact amount of lubricating oil to be fed to a compressor. For a machine of under 10 tons 5 to 7 drops per minute should be sufficient for the cylinder and if 5 drops per minute be fed to stuffing box this oil finally enters the cylinder, insuring ample lubrication.

The comparative low temperature in the cylinder eliminates all danger of gumming rings. The chief danger is in the scoring of the cylinder by badly fitting rings, and as the cylinder is of steel, reboring or replacement is expensive. In putting in new rings they should be fitted to the cylinder. In doing this the surface of the cylinder should be coated with lamp black or red lead for a distance of, say six inches. The ring ends are then pulled together until the ring slips into the cylinder. By pushing on opposite sides of the ring the latter may be moved enough to cause the lamp black to be rubbed off the cylinder into those parts of the ring that touch the cylinder surface. These high spots should be rubbed down with emery paper until the entire ring coats on being shoved into the cylinder. A good fit of the rings is essential for the cylinder diameter is small and the stroke long, making a leak a serious matter.

The condenser is in most units placed very close to the compressor with the intention of eliminating as many joints as possible. If joints are well made either by welding or by the use of special connectors, such as used in high-pressure air lines, leakage may be avoided.

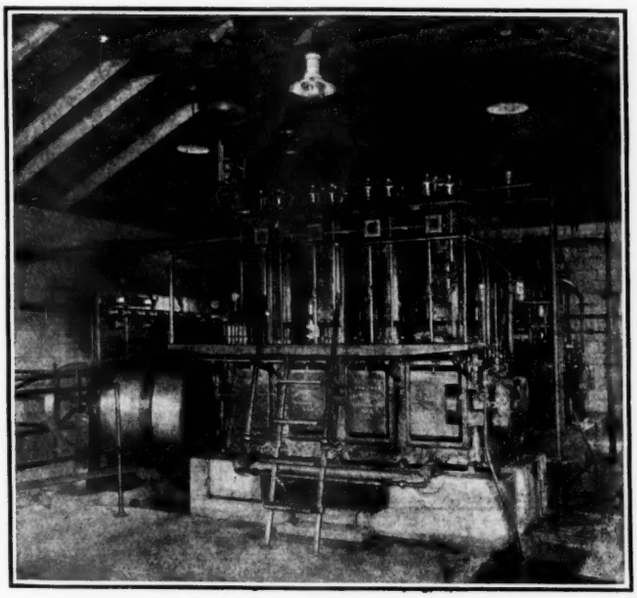
Leakage danger is the objection most often raised against the CO_2 machine. The belief is prevalent that the breathing of carbon dioxide would result in death from poison. This gas, on the contrary is absolutely inert and will not kill one any more than will water. If one is placed in an atmosphere composed of CO_2 death will follow by reason of the exclusion of the life-giving oxygen. Fortunately, carbon dioxide is much heavier than air and when the machine is installed in basement the fumes will settle down close to the floor and will not mix with the air. The system is the safest for hospitals, apartment houses and hotels.

The real objection to leaks comes from the loss of CO_2. If peppermint oil be added to the CO_2 a leak will readily reveal itself by the peppermint odor. To discover the location of the leak, the sense of smell is the best means where peppermint oil has been added to the system. Otherwise the use of soapsuds is the most practical way.

Gas Engines in Municipal Light Plant

While natural gas is largely becoming a fuel for domestic use exclusively, there are many power plants still using this fuel. Much gas is burned in steam plants where the efficiency is exceedingly low. If gas must be used for power purposes the prime movers should be internal-combustion engines.

The municipal power plant at Basin, Wyo., made use of gas-fired steam boilers and non-condensing engines for a number of years. The engines were



Foos Natural Gas as Engines in Basin Municipai Power Plant

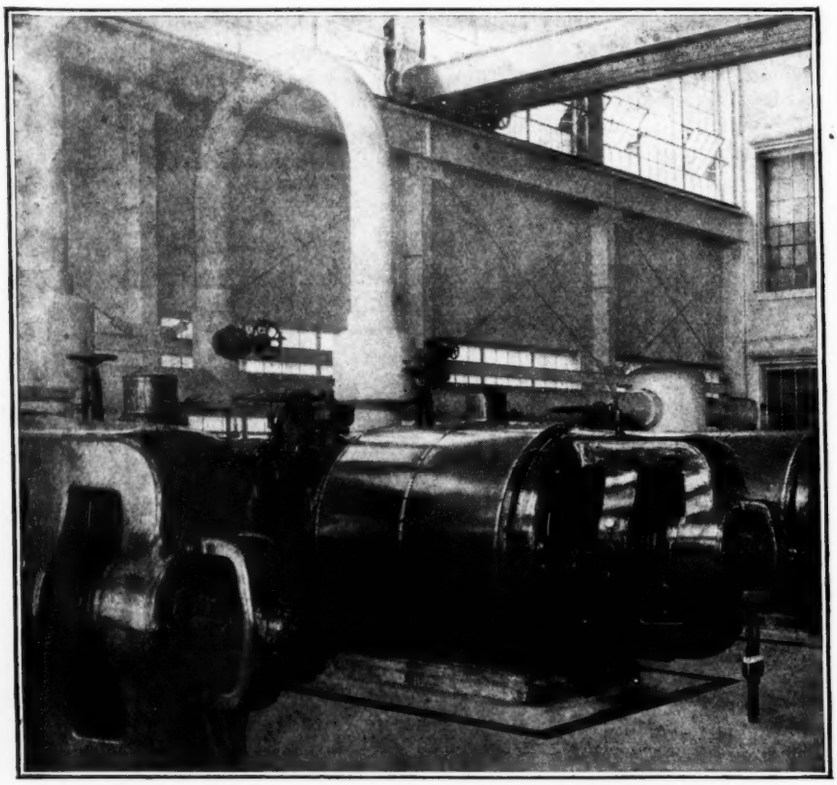
belted to generators supplying current to the town as well as power to the city water pumps. The average daily output was 1,100 kw.-hr. with a gas consumption of 150,000 cu.ft., costing $22.50. The unsatisfactory condition of the plant led to the installation of two 165-hp. four-cylinder four-cycle natural gas engines. One of the units is direct connected to a 125-kw. 2,300-volt, 3-phase, 60-cycle generator, while the second is belted to a 90-kw. machine used in the old powerhouse.

The plant has been in operation for over a year, during which time the gas consumption has averaged 30,000 cu.ft. per day, a saving of eighty per cent compared with the old plant. The net saving in fuel and lubricating oil is $560 per month.

Installing an 1,875-Kva. Impulse Steam Turbine

BY CLAUDE C. BROWN

THERE are a number of important details that should be kept in mind during the installation of a steam turbine, and if carefully attended to during the construction period, will prevent much of the subsequent trouble that sometimes occurs before the unit really is in a satisfactory working condition. Too many times these construction details are slighted, especially where there exists a rush or lack of adequate time in which to get the plant in operation. Any time thus gained is paid for many times over in changes and repairs.



Expansion moves 1,875-kva., 3,600-r.p.m. generator guided on sole plate, away from fixed turbine

The following is a short résumé of a number of these details carefully worked out in the installation of each of the four steam turbo-generators at the plant of one of the larger Western sugar refineries. These four machines operate non-condensing and serve as reducing valves to supply low-pressure steam for the refinery. They are impulse horizontal three-stage units, 3,600 r.p.m., 140-160 lb. throttle pressure, 10-15 lb. exhaust, and rigidly connected to 1,875-kva. 480-volt generators, with direct-connected compound-wound exciters, for 125 volts and 112 amperes.

Foundations for the turbines are of reinforced concrete, having been carried down to bedrock and cast independently of the concrete floors of the power house. The foundation blocks are so designed as to allow the entrance and exit of the generator ventilating ducts and the exit of the 20-in. exhaust steam lines. Great care was taken in their construction in order that they might be not only strong and substantial, but also rigid under all operating conditions. Such precaution is absolutely necessary, especially in the case of high-speed rotative apparatus, in order to maintain the true alignment of the turbines and to minimize vibration.

In this type of prime mover a three-point support system is used. There are two supports or legs under the turbine, each of which should bear an equal weight. Every precaution was taken to see that each generator rested squarely on its support, as the generator is not bolted down but merely rests on wide shims between the stator frame and the sole plate. The connection piece between the turbine and the generator is rigid, and the movement of the generator on its support relieves the assembled unit from expansion strains caused by the varying heat conditions of operation. To prevent the turbine from moving axially, a dowel passes through the turbine foot and the sole plate on the steam entrance side. Keys in the two sole plates guide the expansion of the turbine crosswise to the shaft. Expansion of the assembled unit results in movement of the generator parallel to the shaft in guides on each side of the generator base.

During erection, leveling lengthwise was accomplished by means of finished bosses on the top of the connection piece between the turbine and the generator. Sole plates were kept bearing evenly on the foundation with close-spaced wedges, until the finished bosses were as exactly the same elevation. Cross leveling was then adjusted by means of bosses located on the outboard end of the turbine casing and on the end bearing bracket of the generator. Grouting was forced thoroughly underneath the sole plates by means of a dam and carefully puddled to eliminate air pockets and voids.

Foundation Cleaned Before Pouring Grout

Prior to setting up the unit, the top of the foundation was thoroughly cleaned and grooved so that the grout would make a good bond between sole plates and foundation. Before the grout was put in, this space was carefully blown out with air to remove all débris, chips, etc. The grout, a thin mixture of cement and water, was then poured in and allowed to set three days before any additional weight was put upon the lower half of the frame and casing. This operation

of grouting the unit to the foundation is very important, and any carelessness or laxity in its performance is almost sure to result in a poor and insecure fastening, leading to serious troubles which are difficult to correct.

After the grouting had set permanently, the assembly of the unit was begun. All flange fits were rabbetted and located by dowels or assembly marks. The frame connection pieces, wheel casing, nozzles, bearings, packing boxes and packing rings were split horizontally. In connection with the horizontal joint between the upper and lower halves of the turbine casing, considerable difficulty was encountered in obtaining a steam-tight and watertight joint. Several ways were tried, such as red lead, graphite, shellac, etc., none of which was entirely successful.

Thin Gasket in Casing Joint Does Not Affect Nozzle Alignment

As this joint must be made and remade every time the upper half of the turbine casing is lifted, it is essential that some method be used that will insure a tight joint between these operations. A gasket was finally cut out of sheet packing, ⅛ in. thick and of a width conforming to the bearing face of the joint. This gasket was clouded with graphite and was successfully used and reused several times over. The stationary nozzles being fixed essentially by the lower half of the turbine casing, were thus not displaced.

Every precaution was of course taken in properly lining up each unit. The centers of all machined bores of the steam casing and packings are at the shaft center line. The middle and turbine-end bearings are on the same horizontal center line. The generator-end bearing center is raised slightly above the turbine-bearing centers, and the amount of this deflection is stamped on the end of the generator bearing bracket near the shaft. Proper leveling should produce the required alignment.

Relative positions of the rotating and stationary elements of the steam turbine, the amount of end play and the opposing of the minor end thrust in operation are controlled by means of a double roller thrust bearing placed on the turbine end of the shaft. The end play of the rotating element is limited in the thrust bearing so as to vary from 0.003 to 0.005 in. and may be adjusted by the use of thin U-shaped shims.

The proper method to determine the correct position of the rotating element is first, with the turbine cold, to start up at slow speed, say about 200 r.p.m. Then set the throttle valve at that point, allowing the machine to turn over slowly. Next, turn the adjusting worm in a counterclockwise direction, thus pushing the rotor toward the generator end, until a slight clicking or rubbing noise is heard in the wheel casing, indicating contact between the stationary and rotating elements. Listen by means of a short pipe or rod placed between the ear and the turbine casing.

Cautious Procedure for Setting Clearances

This operation should be performed in a careful and deliberate manner so that the rotating and stationary elements are permitted to rub together only very slightly. While both the rotor and the casing, or rather the stationary elements, are constructed with slightly protruding shoulders for the protection of the moving and stationary blading, serious injury to the elements may result if the parts are brought together roughly or allowed to remain in contact for too great a length of time. As soon as the rubbing is observed, the adjusting worm should be immediately reversed in rotation, track being kept of the number of turns in the clockwise direction while the rotor is being pulled toward the exhaust end of the machine. As soon as the rubbing noise is again noticed, the rotor has arrived at the limit of travel in this reverse direction and should be immediately freed from contact.

The distance that the rotor is moved in an endwise direction for one turn of the adjusting bolt is stamped on the end bearing cap. Hence the number of turns of the adjusting bolt multiplied by the distance that the rotor is moved for one turn gives the total effective clearance of the rotor. On this type of machine this total clearance varies from 0.120 to 0.160 inch.

Periodic Checking of Clearances Reveals Internal Troubles

Having thus determined the total effective clearance of the rotor and the position of the latter now being at the extreme turbine end of its travel, the adjusting bolt should be revolved back in a counterclockwise direction for a distance of one-third of the entire number of turns previously made in the clockwise direction. This moves the rotor a distance of one-third of the total effective clearance toward the generator end. The adjusting bolt should be locked at this point. The expansion of the shaft due to the heat of operation will cause the rotating element to move farther toward the generator end where it will assume a position very near the center of the total effective clearance. If the foregoing adjustment is made when the turbine is hot, after carrying a load, the final setting may be made more nearly at the center of the rotor travel.

Experience at the plant in question has shown that it is good practice to check this adjustment at periodical intervals of one month, for the reason that the relative positions of the stationary and rotating elements of the turbine naturally effect the division of the clearance, and the latter should be equally divided on either side of the rotating blades. Such a check also immediately discloses any variation in the total effective clearance that might be caused by the warping of blades, shrouds or disks.

These turbines as first installed were equipped with bronze blades and nozzles, but after a short period of operation considerable difficulty was encountered in pitting, corrosion or erosion, and wearing away of the blading of the first stage wheel. Investigation disclosed the fact that the trouble was due to moisture in the steam and also to small particles of scale that were being carried over into the turbine from the boilers. Precautions were then taken to furnish the steam as dry and as pure as possible, and the first stage blading of each machine was changed from bronze to monel metal after which no further trouble was experienced.

Pipe Expansion Minimized

The installation of steam piping, both live and exhaust, to any turbine or number of turbines should be as short and straight as possible, but at the same time sufficiently flexible to prevent undue strains being imposed upon the units. Both live and exhaust lines should be anchored and supported properly in order to reduce to a minimum any expansion stresses transmitted to the turbine structure.

The main live-steam header that furnishes the turbines with dry steam at 150 lb. is a 16-in. o.d. welded steel header with Van Stone joints and welded steel nozzles. This covered steel header is installed on brackets on the power-plant wall, the central bracket being an anchor and the others being provided with rollers to take care of the expansion of the line. There is installed in the main header, at a point ahead of the first turbine nozzle, an adequate steam separator of the horizontal type, which is drained by a number of steam traps and a drip tank. The header is graded both ways to this separator.

Careful Pipe Cleaning Failed to Prevent Trouble

At the time of installation of the live-steam piping great care was taken to see that all joints were perfectly matched up and properly made, that all the flanges were parallel before bolting up and that all piping was properly and securely supported and anchored. After the main header was in place, it was thoroughly cleaned out by drawing sacks through it, after which it was blown out with air and steam. In a like manner each of the individual steam bends to the turbines were cleaned and blown out so that the erectors were absolutely sure that no piece of foreign matter remained in the lines.

In spite of these careful and elaborate precautions, when one of the turbines was first started up a small piece of iron about the size of a three-eighths nut was carried into it and in a very few revolutions ripped out the blading of the first stage wheel. It is a very important factor in the erection of steam turbines to spare no time or effort in the thorough cleaning out and preparation of the steam headers and steam supply lines.

Bolted directly to the under side of the steam turbine casings over the exhaust outlets are 20-in. multi-corrugated copper expansion joints, to which are bolted the 20-in. exhaust lines of each turbine, each containing an exhaust gate valve. These exhaust lines from each turbine are connected into the 36-in. exhaust header, which is drained of condensate by means of steam traps on the ground floor of the plant. This exhaust header passes through the power plant into the refinery, where it connects with the exhaust-steam-system network, thus distributing to the various parts of the refining plant. The other end of the exhaust header is connected to a multiport relief valve which is set at 15 lb., at which pressure it allows the exhaust steam to blow through the atmospheric line to the roof of the power plant.

Readjustment to Obtain Smooth Operation

It is a difficult matter to secure perfect balancing of high-speed rotating apparatus. Considerable difficulty was encountered in obtaining satisfactory balance and absence of vibration in the cases of two of these turbines. As stated in the beginning of this article, great care was taken in the construction of the foundations for the turbines, these blocks being carried down to bedrock and brought up to the proper level absolutely independent of the floor slabs. Two of the machines required but little effort and adjustment to put them in satisfactory balance, but the other two had evidently been thrown out of adjustment by shipping and reassembling. Finally, after disassembling and carefully reassembling these two units, and by the insertion and judicious relocation of weights in the end flanges of the revolving fields, good balances were secured.

Every turbine is, of course, carefully and rigorously tested before shipment is made by the manufacturer, all rotating parts being balanced first statically and then dynamically. Vibration and unbalance in a turbine may be due to one or more of the following causes: Improper setting, foundation defects, faulty alignment, contact between rotating and stationary parts, defective shaft packings, insufficient lubrication, wear of shaft or of thrust bearings, defective drainage of piping and of wheel casings, sediment which brought over by the steam, has accumulated on buckets or wheels, and finally, even though the machine has been perfectly balanced at the factory, the jars or strains of shipping or of handling during construction may throw it entirely out of adjustment.

Good balance is highly important for the duration of the bearings and general reliability. The turbine part of the machine should at first be run with the rotor of the generator removed. This should be brought to the best possible balance (by successive trials) attaching weights to the lowest stage wheel. The weights should be screwed into holes threaded in the turbine wheel and riveted over so that they cannot possibly come loose. After the wheels have been balanced, the rotor of the generator should be assembled and balanced by running at all speeds, adding weights where necessary to the flanges of the generator revolving field.

Systematic Control of Boiler-Water Concentration

By C. M. Ware

Blowing down a boiler in excess will amount to an appreciable waste if it is not kept at a minimum. This feature of boiler operation should be controlled in as systematic a manner as any other detail of power-plant operation.

The concentration of the boiler water may materially affect the behavior of the boiler, as at high concentrations of soluble salts and suspended matter foaming may occur. Undoubtedly, a boiler should be operated at its highest, safest and most economical concentration. When it is determined what this shall be, then it should be held at this concentration in a systematic manner. Most manufacturers can recommend approximately what concentration is safe at various ratings for a particular boiler. The true safe concentration can be determined only by test.

The objection may arise that it is impracticable to analyze the water often enough to control its concentration daily. This idea is erroneous, as there are various methods of determining the total solid content of boiler water.

In order to do this, take precautions to get a representative sample. The water should be allowed to cool at boiler pressure before drawing. If this precaution is not taken, flashing will occur and a sample of higher concentration than actually exists will be drawn. An easy method of drawing the sample is to put a small valve and drain on the water column blowdown line in such a place that the column and piping can first be blown down, then allowed to cool at boiler pressure. The water standing in this pipe can then be drawn off. The amount of water should be at least one liter. If this water is too turbulent for the test, it may be allowed

to stand and the suspended matter given time to settle out, or it may be filtered.

One of the three following methods can be applied according to its relative merit for the plant concerned:

The concentration-meter is an electrical device that is handy and easily applied. It consists of a low-voltage meter which indicates the concentration of a sample of the water, which is poured into a small container on the instrument. This method gives the total solid content of the boiler water direct.

A sample of the water can be evaporated in a platinum dish, and the gain in weight indicates the total solids. These total solids can be calculated in parts per hundred thousand depending on the amount of water evaporated.

Blow Down May Be Regulated by Chloride Content

For the small operator these plans may prove expensive, and the second method requires too much time. Because of this the following procedure may prove most convenient:

Owing to the solubility of these salts and the ease with which they may be determined, the blowdown can be regulated by the chloride content alone. There is usually a fairly definite ratio of the chloride to the total solid content of the boiler water. This ratio can be determined by a partial analysis of the boiler water. After this ratio is determined, then it only needs to be checked periodically.

To determine the chloride content, measure out exactly 100 c.c. of the sample and destroy the alkalinity with acid, using phenolphthalein as an indicator. To do this add two drops of phenolphthalein, which will color alkaline water red. Then add sulphuric acid until the water loses the red color. This leaves the water

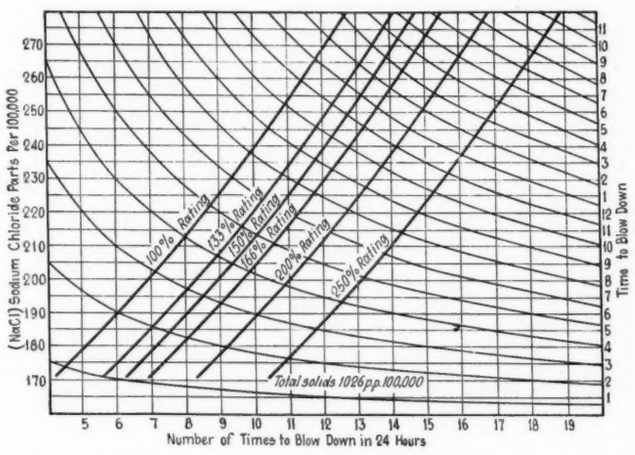


Fig. 1—Chart for determining number of times to blow down to maintain certain concentration of boiler water

neutral for the chloride determination. Drop in one c.c. of a 2 per cent solution of potassium chromate. This will color the sample yellow. Take a solution of silver nitrate of 28.96 grams per liter and by means of a burette drop in enough to change the color to a distinct brick red. Multiply the number of cubic centimeters required to make this change by ten and it will give the chlorine content in parts per hundred thousand. If this is desired in terms of sodium chloride, multiply the final figure by 1.65. If the total solids are desired multiply the sodium chloride by its ratio to the total solids.

If it is assumed that the last method is applied to be used with the accompanying chart, the following is an illustration of its use:

The boiler water tested 205 parts per hundred thousand of sodium chloride. This boiler is to be operated at 166 per cent rating during the next twenty-four hours. With reference to the chart follow the horizontal line from the sodium chloride indicated until the 166 per cent curve is met. From this point drop down the vertical line to the bottom of the chart, where

Time to Blow Down Boilers		
Boiler Number	Date P.M.	A.M.
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
Remarks		

Fig. 2—Water-tenders instructions for blowing down are posted on blackboard

it indicates that the boiler shall be blown down ten times in the next twenty-four hours to reduce the concentration to normal. The normal blowdown for that rating is seven times in twenty-four hours. In other words, if the boiler is operated constantly at 166 per cent rating and it is blown down seven times every twenty-four hours, its concentration will not go above 1,026 parts per hundred thousand. Unusual operation or unforeseen circumstances may be the cause of the concentration going above what is recommended. If the number of blowdowns should result in a decimal, always go to the next larger whole number.

The time of these blowdowns can be arranged by reading from the intersection of the line indicating the number of blowdowns with the time curves on a horizontal line to the right. In this example it would be 1:20, 3:44, 6:08, 8:32, 10:56, 1:20, 3:44, 6:08, 8:32 and 10:56.

A convenient method of instruction for the water tender can be arranged as illustrated by Fig. 2. This blackboard is so arranged that the new schedule for each twenty-four hours can be posted each noon. This requires testing the water once every twenty-four hours.

The chart was compiled for the following assumptions:

1. Concentration of boiler-feed water, 25 parts per 100,000.
2. Possible boiler-water concentration, 1,680 parts per 100,000.
3. Maximum safe boiler-water concentration, 1,026 parts per 100,000.
4. Ratio of sodium chloride to total solids, one to six.
5. Capacity of boiler at normal level, 44,725 pounds.
6. Each blowdown shall be one gage of 2,526 pounds.
7. Boiler rating, steam per hour, 20,700 pounds.

Bids on Equipment for Detroit Municipal Plant

Including Boilers and Superheaters, Condensers, Evaporators and High- and Low-Pressure Extraction Heaters; Other Equipment To Follow

IN THE accompanying tabulations are presented the assembled bids on which the final contracts were let for a variety of equipment to be installed in the new Morrell Street power plant now under construction by the City of Detroit. Five items are covered as previously listed and as soon as action has been taken on the bids, tabulations on other items of equipment, such as economizers, air preheaters and powdered coal equipment, will be available.

All bids, including the alternates, cover the same number of units of the various items of equipment, namely, six boilers (two per turbine), three condensers, three evaporators, three high-pressure extraction heaters, three low-pressure and three intermediate-pressure extraction heaters.

Last year it will be recalled that boiler, turbine and condenser specifications with the tabulated bids were published in these columns. The schedule of boiler bids appeared in the Aug. 28, 1923, issue, the turbine specifications and bids Nov. 27, and the condenser specifications and bids Dec. 11, 1923. At that time the generating units were purchased, but for certain definite reasons the bids on other equipment were rejected and the entire project held up for a number of months until the city had an opportunity by popular vote to raise its bonding limits to permit taking on the obligations imposed by the new plant. New specifications with slightly modified requirements were then sent out by Smith, Hinchman & Grylls, consulting engineers, and the bids received and tabulated as per the accompanying tables. The successful bidders to which contracts were awarded are as follows:

Boilers, including superheaters....W. E. Wood Co.,
Condensers .....C. H. Wheeler Mfg. Co.,
Evaporators .....Griscom-Russell Co.,
High-pressure extraction heaters....Cochrane Corp.
Low-pressure extraction heaters..Alberger Heater Co.

SCHEDULE OF BIDS HIGH PRESSURE EXTRACTION HEATERS MORRELL ST. PLANT

I Bidder II Address					Cochrane Corp. Philadelphia, Pa.		Griscom-Russell Co. New York, N. Y.		Ross Heater & Mfg. Co. Buffalo, N. Y.	
III Price					$15,850	Per Cent Tol.	Bid Not Regular Comb. Price, See Evap. Bids	Per Cent Tol.	$27,370	Per Cent Tol.
1. Delivery time, weeks					16	25	15	10	12	2 weeks
2. Erection time, weeks					2	25	1	..	3	½ week
3. Net weight, assembled, lb.					30,000	10	.....	..	29,500	5
	Lb. abs.	Lb. per hr.	Deg. F in	Deg. F. out						
4. C.C. of oxygen per liter when the extracted st. press. (superheated 75 deg. F.); and the quantities and temp. of water deaerated are as follows:	32	106,000	177	254	0.018	50	.....	..	0.010	5
	45	149,000	191	275	0.018	50	.....	..	0.020	5
	62	200,000	205	294	0.018	50	0.03 C.C. for any Temp. rise over 25 deg. F.	..	0.025	5
	82	263,000	217	312	0.018	50	.....	..	0.030	5
5. Water storage capacity per heater, lb.					500 cu.ft.	..	30,000	5	30,000	2

In the boiler table it should be pointed out that the W. E. Wood Company's bid includes Babcock & Wilcox boilers and Foster combination type superheaters. This particular bid and the original bid of the D. Connelly Boiler Co. are the only bids complying with the specifications. The others are alternate bids submitted for the consideration of the Commission. Owing to lack of space one alternate bid of $450,000 by the D. Connelly Boiler Co. has been omitted from the table. This included a Foster combination type superheater.

The boiler units are smaller in the present case than in the bids submitted last year and instead of the interdeck type of superheater being specified the combination radiant-heat and convection type has been adopted.

SCHEDULE OF BIDS EVAPORATING UNITS, MORRELL ST. PLANT

I Bidder II Address			Griscom-Russell Co. New York, N. Y.		Wheeler Cond. & Eng. Co. Carteret, N. J. Submerged Type		Wheeler Cond. & Eng. Co. Carteret, N. J. Film Type		Ross Heater & Mfg. Co Buffalo, N. Y.	
III Price			$11,148	Per Cent Tol.	$13,680	Per Cent Tol.	$16,695	Per Cent Tol.		
1. Delivery time, weeks			15	10	12	15	12	15	.....	....
2. Erection time, weeks			1	..	6	15	6	15	.....	....
3. Net weight of preheater, lb.			1475	5	1830	5	1830	5	.....	....
4. Heating surface per preheater, sq.ft.			48.8	1	32.0	0	32.0	0	.....	....
5. Net weight of evaporator, lb.			9,150	5	17,000	5	20,000	5	.....	....
6. Heating surface per evaporator, sq.ft.			160	1	152	0	152	0	.....	....
7. Weight of extraction steam at 62 lb. abs. to produce 5,500 lb. of vapor at 14.8 lb. abs.			5,890	5 to 10	5,960	3	5,960	3	.....	....
	lb.	abs.								
8. Weight, lb of vapor produced, from water at 202 deg.F., when vapor and extraction steam pressures are as follows:	7.9	32	4,700	40	4,800	+20	6,550	+10	.....	....
	10.9	45	5,230	40	5,300	+20	7,250	+10	.....	....
	14.8	62	5,500	40	5,500	+20	7,500	+10	.....	....
	19.3	82	5,800	40	5,950	+20	8,150	+10	.....	....
9. Water in evap. at normal level, lb.			5,340	10	2,200	15	450	20	.....	....
10. Combination price..... Sections included			H, I, & J.		F, H. & J.		F, H, & J.		I, & J.	
Price			$47,235.00		$191,000.00		$194,000.00		$32,447.25	....

Section F = Condenser units; H = Evaporator units; I = H.P. Extraction heaters; J = L.P. and I.P. Extr. heaters.

SCHEDULE OF BIDS ON LOW AND INTERMEDIATE PRESSURE EXTRACTION HEATERS, MORRELL STREET PLANT

I Bidder		Alberger Heater Co.	Andale Engineering Co.	Elliott Co.		Griscom-Russell Co.		Ross Heater & Mfg. Co.	Westinghouse E. & M. Co.	Wheeler Cond & Eng. Co.
II Address		Buffalo, N. Y.	1015 Chestnut St., Philadelphia, Pa.	Pittsburgh, Pa.		90 West St., New York, N. Y.		Buffalo, N. Y.	East Pittsburgh, Pa.	Carteret, N. J
				Proposal A	Proposal B	Proposal A	Proposal B			
III Price		$9,550	$25,385	$13,116	$15,390	$14,202	$14,097	$12,785	$14,750	$13,100
1. Delivery time, weeks		8	12 to 16	12	12	15	15	12	3 heaters-28 wks. / 6 heaters-50 wks.	12
2. Net weight of L.P. heater, assembled, lb		8,650	14,790	10,500	15,000	12,400		8,980	10,200	8,700
3. Net weight of I.P. heater, assembled, lb		10,500	15,060	10,500	15,000	12,000		8,980	9,500	8,800
4. Tubes in L.P. heater	Heating surface, sq.ft.	960	1,540	1,090	1,240	1,028	958	940	915	865
	Length and outside diam	10′–0″ 3/4″	10′–7 3/8″ 5/8″	12′–8 1/2″ 5/8″	9′–0″ 3/4″	8′–7″ 5/8″		10′–0″ 3/4″	8′–2 1/2″ 5/8″	12′–0″ 3/4″
5. Tubes in I.P. heater	Heating surface, sq.ft.	1,100	1,650	1,090	1,240	992	1012	940	760	920
	Length and outside diam	10′–0″ 3/4″	10′–2 3/8″ 5/8″	12′–8 1/2″ 5/8″	9′–0″ 5/8″	7′–10″ 3/4″		10′–0″ 3/4″	6′–10 1/2″ 5/8″	12′–0″ 3/4″
6. Coef. of heat transfer in L.P. heater at normal load, B.t.u. per hr. per sq.ft. per deg. F		412	300	260	228	385		435	430	500
7. Coef. of heat transfer in I.P. heater at normal load, B.t.u. per hr. per sq.ft. per deg. F		418	300	300	264	465		490	600	500
8. Min. temp. rise (deg. F.) of water in L.P. heater when weight of water, inlet water temp., and pressure of 94°C dry steam are as follows:	Lb. per hr. / Deg. F. / Lb. abs.									
	93,000 / 83 / 1.9	39.0	32.0	37.0	37.0	38.5		37.9	36.0	34.5
	130,000 / 82 / 2.7	51.5	45.5	50.0	50.0	51.4		50.5	49.0	50.0
	174,000 / 81 / 3.6	61.0	61.0	61.0	61.0	61.0	61.0	61.0	61.0	61.0
	227,000 / 86 / 4.8	64.0	66.5	67.0	67.0	64.6		68.5	67.0	66.0
9. Min. temp. rise (deg. F.) of water in I.P. heater when weight of water, inlet water temp., and pressure of 98°C dry steam are as follows:	106,000 / 119 / 7.9	60.0	47.5	58.0	58.0	59.8		59.9	57.0	56.0
	149,000 / 131 / 10.9	61.0	55.0	59.0	59.0	62.0		61.8	60.0	59.0
	200,000 / 142 / 14.8	63.0	63.0	63.0	63.0	63.0	63.0	64.0	63.0	63.0
	263,000 / 152 / 19.3	63.5	64.0	65.0	65.0	64.5		62.8	64.0	66.0
10. Pressure drop (lb. sq.in.) from water inlet to outlet of L.P. heater when water circulated is:	93,000	0.80	1.43	1.20	1.10	0.905		0.60	0.78	2.00 Ft.
	130,000	1.30	1.91	2.40	2.20	1.566		1.10	1.73	3.10 Ft.
	174,000	2.10	2.50	4.40	4.00	2.47	2.47—	1.60	2.25	7.09 Ft.
	227,000	3.50	3.40	6.40	6.60	3.62		2.30	3.40	12.10 Ft.
11. Pressure drop (lb. sq.in.) from water inlet to outlet of I.P. heater when water circulated is:	106,000	0.80	1.35	1.60	1.50	0.978		0.70	0.91	2.40 Ft.
	149,000	1.30	1.82	3.20	2.80	1.62		1.20	1.50	4.70 Ft.
	200,000	2.20	2.50	5.80	5.20	2.50	2.52+	1.80	2.50	8.24 Ft.
	263,000	3.50	3.26	9.90	8.90	3.80		2.90	4.10	14.40 Ft
12. Combination price	Sections included						H, I, & J.	I. & J.		F. H. & J.
	Price						$47,235	$32,447.25		See Evaporator bid

Section F = Condenser units; H = Evaporator units; I = H.P. Extraction heaters; J = L.P. and I.P. Extraction heaters.

SCHEDULE OF CONDENSER BIDS MORRELL STREET PLANT, PUBLIC LIGHTING COMMISSION, CITY OF DETROIT

I Bidder		Allis-Chalmers Mfg. Co.	Elliott Co.		Ingersoll-Rand Co.	Westinghouse E. & M. Co.	C. H. Wheeler Mfg. Co.	Wheeler Cond. & Eng. Co.	Worthington Pump & Mach. Corp.	
II Price		$182,000	$156,000	$165,000	$162,500	$240,000	$144,000	$167,900	$216,000	$201,000
1. Delivery time, weeks		52	24		52	32	30	25	32	
2. Erection time, weeks		12	28		60	18	18	10	13	
3. Net wt. of condenser without tubes and ferrules, lb.		173,000	220,000		125,000	159,000	185,000	125,000	178,000	
4. Net wt. of circulating pump without sub-base, lb.		8,050	12,000		14,000	11,125	16,500	15,000	20,000	
5. Net wt. of condensate pump without sub-base, lb.		1,500	2,000				2,800	6,500	4,000	
6. Tube surface per condenser, sq.ft.		27,000	27,000		14,250	27,000	27,000	27,000	27,000	
7. Circulating water (g.p.m.)	1. Circulating pump operating	23,000	20,300	22,000	21,500	24,500	23,000	24,000	27,000	20,000
	2. Circulating pumps operating	36,000	36,000	36,000	36,000	36,000	36,000	36,000	36,000	36,000
8. Abs. back pressure (in. of hg.), Two circulating pumps running, 55 deg. F. water, and condensing the following amounts of steam:	220,000 lb. per hr.	1.00	0.90		1.05	1.02	0.89	1.0	1.0	
	175,000 lb. per hr.	0.90	0.80		0.90	0.86	0.76	1.0	1.0	
	130,000 lb. per hr.	0.82	0.80		0.80	0.73	0.66	1.0	1.0	
	95,000 lb. per hr.	0.78	0.80		0.80	0.64	0.60	1.0	1.0	
9. Abs. back pressure (in. of mercury), one circulating pump running, 55 deg. F. water, and condensing the following amounts of steam:	175,000 lb. per hr.	1.05	1.00	0.97	1.15	0.99	0.97	1.0	1.0	1.97
	130,000 lb. per hr.	0.90	0.82	0.80	0.90	0.80	0.80	1.0	1.0	1.00
	95,000 lb. per hr.	0.82	0.80	0.80	0.80	0.69	0.68	1.0	1.0	1.00
10. Loss of head, ft., when 36,000 g.p.m. of circulating water is passing condenser.	Through condenser	17	15.0		14.4	16.0	13.9	13.0	13.65	
	Through piping	3	4.4		3.1	2.0	1.0	2.0	3.84	
	Siphon loss	1	1.6		0.5	2.0	3.0	1.0	1.00	
	Difference in water levels	2	2.0		2.0	2.0	2.0	2.0	2.00	
	Total head on pumps	23	23.0		20.0	22.0	20.0	18.0	20.49	21.5
11. Characteristics of circulating pumps when 36,000 g.p.m. of circulating water is passing condenser, and when suction lift is 8 ft.	Horsepower	123	130		110.0	132	114.0	105	121.0	133
	Speed, r.p.m.	353	420		345.0	490	350	290	360.0	400
	Efficiency, per cent.	85	80		83.0	76	80	78	77	70
12. Condensate pump characteristics:	Horsepower	82	89.8		105.0		90	96	100	
	Speed, r.p.m.	1,750	1,740		1,750		1,750	1,750	1,200	
	Head, feet	376	380		382	381	380	380	340	
	Efficiency, per cent.	64	64		55		64	60	55	
13. Steam required, lb. per hr., for each air removal equipment.	For first stage	190	120		200	190	310	300	189	
	For second stage	750	300		600	515	440	300	441	
14. Loss of head, ft., through inter and after condensers, when condensate pump is discharging 600 G.p.m.		6.5	6		10	8	5	5	8	
15. Temp. difference, deg. F., between exhaust steam entering cond. and cond. leaving hotwell, 55 deg. F. water, and steam condensed as follows:	175,000 lb. per hr.	5.0	1		2 Deg. F.	2.1	1	1	2	
	130,000 lb. per hr.	7.0	1			2.2	1	2	2	
	95,000 lb. per hr.	10.5	1			2.6	2	3	3	
16. Pressure drop, in. hg., from exhaust steam inlet to air offtake; steam condensed = 175,000 lb. per hr. at 1 in. abs back press.		0.1	0.05			0.15	0.05	0.05	0.15	

SCHEDULE OF BOILER BIDS MORRELL STREET PLANT, PUBLIC LIGHTING COMMISSION, CITY OF DETROIT

	I Bidder	Badenhausen		D. Connelly Boiler Co.				Geo. T. Ladd Co.		Wickes Boiler Co.		W. E. Wood
		Original	Alternate A	B	C	D	E	F	Alternate I	II	III	IV	Mich.
III	Price, 6 boilers	$276,000	$590,000	$450,000	$439,000	$411,000	$441,000	$430,000	$402,000	$626,320	$512,709	$349,343	$335,313	$324,595	$545,991
1.	Delivery time, weeks	28	20							32	25	25	25	25	26
2.	Erection time, weeks	28	31							24	20	20	20	20	30
3.	Net weight per boiler, lb.	190,000	210,000							180,000	210,000	210,000	210,000	210,000	218,000
4.	Water holding capacity per boiler, lb.	66,000	78,000							75,000	85,650	85,650	85,650	85,650	56,300
5.	Heating surface per boiler, sq.ft.	9,600	9,560							9,500	9,540	9,540	9,540	9,540	9,571
6.	Width of boiler, ft.	18'-10"	19'-0"							19'-0"	22'-1"	22'-1"	22'-1"	22'-1"	19'-0"
7.	Weight and surface per section of convected surface. Weight, lb.	15,000	42,000	26,000	40,000	26,000	26,000	40,000	42,000	30,000	42,000	26,000	26,000	40,000	42,000
	Surface, sq.ft.	1,700	3,420	1,635	2,640	1,635	1,635	2,640	3,420	1,925	3,420	1,635	1,635	2,640	3,420
8.	Weight and surface per superheater of radiant surface. Weight, lb.		50,000	26,000	19,500	26,000	19,500		50,000	92,000	50,000	26,000	19,500		50,000
	Surface, sq.ft.		219	280	440	280	440		219	437	219	280	440		219
9.	Max. moisture per cent in steam at nozzle when evaporation is: 5° F. S'h		1.0							1.0	1.25	1.25	1.25	1.25	1.5
	5° F. S'h		1.5							1.0	2.00	2.00	2.00	2.00	1.5
10.	Draft loss (inches of water) through boiler and superheater when weight of flue gas is: 200,000 lb. per hr.		0.28							0.2	0.2	0.2	0.2	0.2	0.15
	62,000 lb. per hr.		0.40							0.8	1.1	1.1	1.1	1.1	0.60
	116,000 lb. per hr.		1.00							1.5	2.3	2.3	2.3	2.3	1.40
	173,000 lb. per hr.		1.75												
11.	Outlet temp. (deg. F.) of flue gas when furnace temp. is 2,500 deg. F.; and evaporation, superheat, and weight of flue gas are: Lb. per hr. / Deg. F. / Lb. per hr. 50,000		485							485	500	500	500	500	*610
	100,000		590							570	640	640	640	640	*765
	150,000		680							625	780	780	780	780	*935
	200,000		700							695	700	690	690	690	700
12	Temperature of steam at superheater outlet (deg. F.) when evaporation is: 50,000		710		690	690	690	690		710	710	710	710	710	710
	100,000		710		710	710	710	710		710	720	720	720	720	695
	150,000		695		720	720	720	720		720	720	720	720	720	695
	200,000		710		720	3.5	3.5	2		2.0	3.5	3.5	3.5	2	1.25
13.	Pressure drop (lb. per sq.in) through superheater when evaporation is: 50,000		3.0	1.25	3.5			3.5		1.25	10.0	10.0	10.0	6	5.00
	100,000		5.0	5.0	10.0	10.0	10.0	10.0		5.00	10.0	10.0	10.0	12	11.25
	150,000		6.0	9.5	11.25	20.0	20.0	2.00		7.0	20.0	20.0	20.0	12	10.20 Add.
14.	Deduct per boiler tube omitted and openings capped, $		18	13						14.0	10.50	10.50	10.50	10.50	10.00 Ded.
15.	Add or deduct per boiler section added or omitted, $		580	1,100											560.00
16.	Add or deduct per sq.ft. of furnace water-wall added or omitted, $		7	25											25.00
17.	Deduct for omitting furnace water-walls, $		52,000	240,000						321,750.00	240,000.00	95,554.00	97,554.00	105,636.00	244,800.00
18.	Deduct for omitting rear furnace water-walls only, $		14,000	45,000						107,250.00	45,000.00	19,200.00	19,200.00	19,200.00	45,900.00
19.	Type of boiler		Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	Vert.	Hor.	Hor.	Hor.	Hor.	Hor.
20.	Type of header		Sect.	Sect.	Sect.	Sect.	Sect.	Sect.	Sect.		Box	Box	Box	Box	Sect.
21.	Type of header		Foster	Elesco-C.S.	El'co-Tube	Elesco	El'co-Tube	Elesco	Elesco	El'co-Conv.	Foster	Elesco-C.S.	El'co-Tube	Elesco	Foster
22.	Type of superheater		Baden.	Comb.	Comb.	Convection	Comb.	Convection	Foster Rad.	Comb.	Comb.	Comb.	Comb.	Convection	Comb.
			Convection	Comb.	Elesco	Elesco	Com.E.Co.	Com.E.Co.		Foster	Elesco	Elesco	Elesco	Elesco	Foster
23.	Make of water-walls		Baden.	Foster											

* Neglecting effect of furnace water-walls.

Pressures in a 36-Mile Steam Column

In any stationary column of fluid the pressure increases with depth. With a non-compressible fluid, such as water or mercury, this increase in pressure is directly proportionate to the depth, but in the case of a compressible fluid the rate continually increases.

In either case the pressure (in pounds per square inch) at any depth is equal to that at the surface plus the weight of a column of fluid one inch square reaching from the given level to the surface. Where the fluid is mercury, water or some other practically incompressible liquid the weight of such a column is directly proportional to its height and is not affected by the pressure at the free surface. The pressure increases in a column of water at the rate of 0.434 lb. per square inch for each foot of depth. With mercury the increase is 0.49 lb. per sq.in. for each inch or 5.89 lb. per sq.in. for each foot.

In the case of a compressible fluid the density increases with the pressure. By increasing the weight of the column of gas or vapor, this in turn produces a further increase of pressure. An aviator descending at a uniform rate from a great height would find that the barometer reading increased more and more rapidly as he neared the ground. The rate would continue to increase if he could descend into a deep hole in the earth's crust.

PRESSURE OF A COLUMN OF SATURATED STEAM

Depth, Miles	Pressure, lb. per sq. in., absolute	Depth, Miles	Pressure, lb. per sq. in., absolute
0	15.0	19	80.4
1	16.5		
2	18.0	20	87.5
3	19.8	21	95.0
4	21.7	22	103.0
		23	112.0
5	23.8	24	122.0
6	26.0		
7	28.5	25	132.0
8	31.1	26	143.0
9	34.0	27	156.0
		28	169.0
10	37.2	29	183.0
11	40.6		
12	44.3	30	198.0
13	48.3	31	215.0
14	52.6	32	232.0
		33	252.0
15	57.3	34	273.0
16	62.4		
17	68.0	35	295.0
18	73.9	36	319.0

This question of pressure increase with depth is of incidental interest in connection with Sir Charles Parsons' proposal to sink a twelve-mile shaft in the earth's crust for investigating its structure and possibly tapping the earth's heat.

In the preparation of the article "Tapping the Earth's Heat," which appeared in the Oct. 7 issue, the pressures in a column of steam 36 miles high were computed for each mile, assuming the pressure at the top to be 15 lb. absolute. The table shows an increase of 1.5 lb. for the first mile, 3.2 lb. for the 10th, 7.1 for the 20th, 15 for the 30th and so on, thus showing the marked effect of compressibility on the increase of pressure.

For any given pressure at the bottom of a hole of any given depth, find this pressure in the table and count up a number of miles equal to the depth of the hole. There read the pressure at the top. As an example suppose the pressure at the bottom of a twelve-mile hole is 215 lb. absolute. Finding this pressure in the table and counting up twelve miles it is seen the pressure at the top will be 80.4 lb. absolute. This table assumes a stationary column of dry saturated steam.

Getting a Vacuum Without a Condenser

ONE of the reasons for the failure of so many isolated plants to make power cheaply is the unwillingness of the designer to avail himself of the advantages of modern engineering equipment. So thoroughly are engineers drilled in the belief that only in exceptional circumstances can an industrial power plant be run condensing, that most are quite satisfied with atmospheric-exhaust conditions.

It is probable that in many localities, especially in congested districts, sufficient cooling water is not available nor are cooling towers permissible. This obstruction to operating under vacuum, or sub-atmospheric, exhaust conditions are not so unsurmountable as they seem. While condensing water is most desirable, it is not absolutely necessary, for it is possible to operate a reciprocating engine under a vacuum, more or less equivalent to condensing conditions, without a drop of water or the semblance of a condenser.

The possibilities of using the kinetic energy in the exhaust of a unaflow engine to induce a vacuum in the cylinder has been discussed in *Power* a number of times. Unfortunately, the entire argument had to be based on theoretical reasoning, assisted by observed phenomena as to the action of two-stroke-cycle gas engines fitted with exhaust pipes of such length that the pressure wave was below atmospheric at the time the exhaust port was uncovered. Since the two- and three-cylinder arrangement of the locomotive made the vacuum exhaust more easily accomplished, experiments have been conducted on a unaflow locomotive, of Russian ownership. Professor Stumpf reports that the vacuum obtained was nearly sixty per cent of that theoretically possible; that is, over fifteen inches of vacuum was obtained.

The same arrangement is possible with a single-cylinder engine, although the vacuum will be somewhat less. The economy given by such exhaust conditions as compared with the usual atmosphere back pressure is more than enough to justify engineers and builders adopting the scheme.

Sludging of Turbine Oil

NOT long ago the precipitates, or sludges formed in turbine oil systems received comparatively little attention. Such matters usually were left to the attention of the man who cleaned the system; if trouble developed, another grade of oil was perhaps tried out.

Lubrication has slowly become recognized as a vital and somewhat elusive subject. Sludges were observed to have two general characteristics: One kind usually occurred in the lower regions of the oil systems and was fairly easy to clean out, while another was largely deposited around bearing liners or the hotter parts and proved difficult to remove, and seemed asphaltic in character. Later on, the first type of precipitate was recognized as being both soluble and insoluble under different circumstances. When first formed, it is difficult to separate from solution. On being further developed, it readily precipitates when oil is cooled and allowed to stand for a necessary time interval.

A valuable addition to the knowledge of mineral oils resulted from an investigation of the possibilities of testing oil stability by exposing samples to oxygen, as described in a recent issue. The soluble sludge is here recognized as composed of asphaltic resins, such as are ordinarily present in crudes. When these were further developed by oxidation into a substance mentioned as asphaltine, this could be precipitated by suitable means. The third variety here spoken of as varnish which sticks tightly, being difficult of removal, is apparently the utmost product of oxidation short of actual combustion.

The investigation also brought out that when exposed to pure oxygen, less than one-half per cent of precipitate could be formed at temperatures below the boiling point, while varnish readily develops in oil vapors at a comparatively few degrees above. The advisability of moderate temperatures in the oil system is thus further evidenced.

At the present time there is almost a total lack of tests whereby the behavior of a lubricant can be definitely predicted in actual operation where conditions are appreciably adverse. A good lubricant is generally recognized as a sound investment, and conditions have not approached the point where inferior oil is an economic necessity. Undoubtedly, much work remains to be done in readjusting bearings to future conditions wherein pure mineral oil becomes an undesirably expensive medium.

Toronto

IF VARIETY is the spice of life, the lot of the modern power-plant designer cannot be entirely drab. More often than not new stations embody one or more departures from current practice. At the risk of an occasional slip in assigning credit, a few of these innovations may be mentioned, attention being confined to large new stations even where some previous applications to old plants have been made.

A few years ago Lakeside broke the ice for powdered fuel in the central-station field. Then Waukegan put four hundred-pound steam pressure on the map. Philo raised the figure to five hundred and fifty pounds and Weymouth to 1,200 pounds. Waukegan is also reported to have had the first chain-grate stokers driven by alternating-current motors.

During the present year we have had Devon, the first large station originally built with electrically operated centralized combustion control, Hudson Avenue with the world's largest condensers, largest generators and largest single-shaft turbines, and Trenton Channel, with

electrostatic dust precipitators, an ingenious arrangement of alternating- and direct-current house turbogenerators and other novel features.

In one respect—the system of heat balance employed—it might almost be said that every new station involves something novel, although some of these apparent innovations are merely new chords struck on the same old keyboard.

The Toronto station of the Ohio River Edison Company, a preliminary account of which appears in this issue, is following the usual custom by being *unusual* in several respects. So far as can be ascertained, this is the first new central station to be equipped with pneumatic centralized combustion control, although this honor may be disputed by the Hudson Avenue station of the Brooklyn Edison Co., which is now installing such control after a few months of operation.

The atmospheric relief valve has been abolished in the Toronto Station, its place being taken by an automatic device that cuts off the throttle steam when the vacuum fails. A rupturing diaphragm is provided as an auxiliary protection for the condenser. An unusual but probably not unique feature is the construction of the substructure as a single watertight "box" extending far below the high-water level. Finally, both the ventilating system and the method of heat balance embody new ideas or at least new combinations of old ideas.

While change is not synonymous with progress, a good share of the innovations of the last few years have so definitely proved their worth that they will not be abandoned except for something still better. Toronto bids fair to make further contributions to the constantly developing field of power-plant design.

Where Do They Get It?

AT SOME time and in some way some misguided soul fell upon the idea that development of water power was a cure-all for all our power difficulties. This fallacy has taken a hold of the public mind and will not let go, or at least certain interests are not going to allow it to do so as long as it can be used to serve political and other purposes. Looking back over the history of water-power development, the records indicate that there has been a tremendous amount of grief connected with such projects, not only from the financial side but also in power shortages due to droughts or otherwise.

Water power is one of our great natural resources and if properly developed and utilized is of inestimable value, but it is not going to revolutionize the power industry, nor does it necessarily mean cheap power even at the source of production, let alone two or three hundred miles away. A recent survey made for the Associated Industries of Massachusetts showed that the cost of developing the available water power in New England would vary from about fifty to five-hundred dollars per horsepower for land and water rights, changes in roads and railroads, and the power plant and structure up to the outgoing lines.

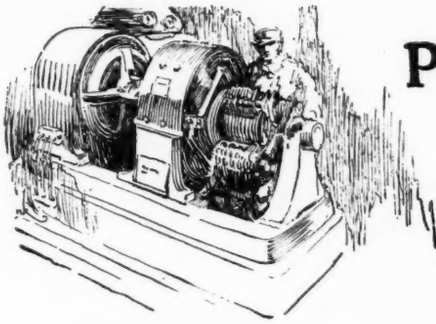
Here is a difference of ten times in the cost of development alone. If other conditions are favorable, the development that costs fifty dollars per horsepower will produce cheap power at the plant. The cost to the consumer will depend upon the length of transmission line, the amount of steam reserve necessary to insure the power supply against the effects of drought or other contingencies, the load factor, etc. On the other hand, the development that costs five hundred dollars per horsepower is impossible financially, at least at the present prices of coal.

There are few places in the country where water power can be depended upon to carry the entire load, and even where this is so the peak load generally can be carried more cheaply by a steam plant, especially if coal is obtainable at a reasonable rate. California, with all its wonderful water-power resources, is passing through a serious power shortage due to the worst drought ever experienced in that part of the country. The Southeastern section of the country, with abundant water-power resources, has found by experience that these cannot be depended upon entirely to supply the power needed during droughts and, like California, is providing steam-plant reserves against emergencies, all of which must be reflected in the cost of producing and distributing power.

Niagara Falls power is cheap power when produced at a high load factor and used in large blocks at or near the source, but if transmitted into the metropolitan area of New York City, could barely compete with local steam plants. Recent studies made by the Northeast Superpower Committee under Secretary Hoover's direction showed that where local steam and hydro plants can deliver power into the systems included in the metropolitan area of New York City at a cost of eleven mills, Niagara or St. Lawrence power would reduce this cost slightly more than one mill. This report shows that nowhere in the whole of the Northeast superpower zone does the cost of water power have any great advantage over steam power except in the vicinity of Niagara Falls and Buffalo. If these figures mean anything, they show that the development of water power is not a panacea for all our economic ills as some would have us think.

Power plants would be more efficient if the men were allowed to work more with their heads and less with their muscles. Why is it that a new engineer so often makes such a good showing at the start? He may be no better than the man he replaced. He may not be given any more equipment or consideration than his predecessor. But he is a new man on the job and everything is new to him. He does not take things for granted. He has not become "ground in" as a cog in the wheel, nor enveloped by routine or habit. He is not blasé, accustomed or blinded by daily routine. Everything is new—and things the other man failed to see the new man sees. Then, again, he brings to his new job enthusiasm and a determination to make good. On the alert, he has his eyes open to see faults and make improvements. Because he is looking for things he finds them, so he gets results.

Henry Ford is reported to have withdrawn his Muscle Shoals offer, observing that the matter has become a political affair upon which business cannot afford to wait. Moreover, experience at River Rouge and his acquisition of extensive coal fields in Kentucky have convinced him that power can be generated cheaper with steam than with water at Muscle Shoals. If this be true, bearing in mind the relatively low figure stipulated in the Ford offer, it should serve to check certain individuals who are proclaiming too much of this development as a source of abundant cheap power, whether publicly or privately developed.



Practical Ideas *from* Practical Men

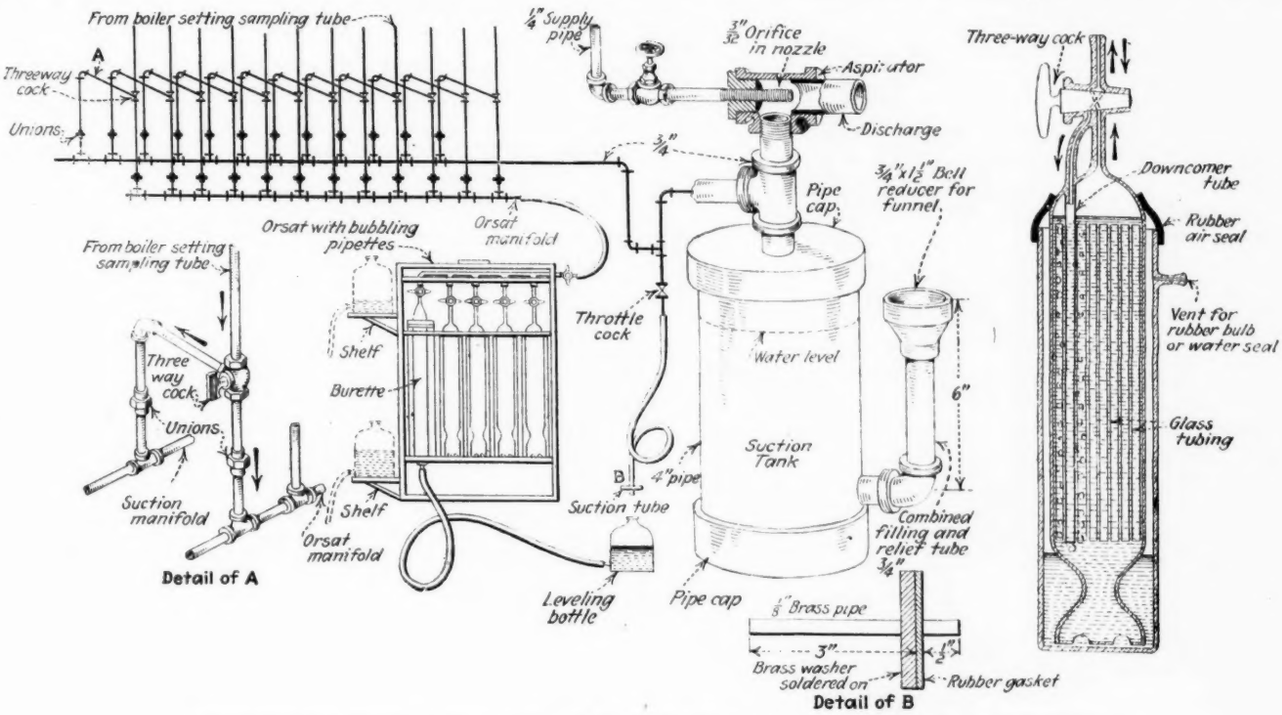
Handling Twelve Boilers with One Orsat

Readers of *Power* may be interested in the details of a hook-up whereby twelve large boilers are effectively served by a single Orsat. The general scheme, along with some of the details is shown in the accompanying drawing.

In order to facilitate the taking of readings, ¼-in. pipe lines are run from the several boiler-setting sampling tubes to a central receiving manifold and suction tank. The tank and aspirator are made of pipe fittings and operated with a steam jet. A very small jet provides all required suction.

It will be seen that the suction is limited to six inches of water by the ¾-in. relief pipe. This amount of suction has been found to be ample. During normal operation all of the sampling lines discharge into the suction tank and fresh samples of gas are instantly available. When taking a sample for the Orsat the proper three-way cock is given a quarter turn, thus connecting the Orsat manifold to the sampling line. The suction tube is then held down on the top of the leveling bottle and a stream of gas is drawn through the Orsat. After a sufficient volume of gas has been drawn through the apparatus, the suction tube is taken from the leveling bottle and the three-way cock is then turned back to its original position. The regular Orsat manipulations are then completed. The throttle cock on the suction-tube connection need not be turned off after each operation.

It is apparent that the time lag between the boiler setting and the Orsat has been cut down to a minimum and that changing furnace conditions can be closely followed. A complete purging of the gas apparatus as well as a clean sample of gas is provided by the one-way movement of gas, via the suction tube and



Arrangement permits true sample to be taken without delay, from any furnace

leveling bottle. The tiresome pumping of gas, either with the leveling bottle or the syringe bulb, is not required. Moreover, the water in the leveling bottle is completely saturated with the gas.

The ordinary Orsat has the three-way cock on the left and the measuring burette on the right. Manipulation can be speeded up (for a right-handed operator) by reversing the apparatus, thus placing all cocks on the right.

Two useful shelves for the leveling bottle can be attached to the measuring-burette side of the rack. The upper shelf should be of a height which will bring the water level to the top of the measuring burette when the leveling bottle is placed on the shelf. The lower shelf should be so placed as to bring the water

level about ½ in. below the zero on the measuring burette. With this arrangement, the zero level can be reached by tilting the bottle or by using the little finger as a steady rest between the shelf and the bottle.

A bubbling pipette, of the type shown at the right of the cut, will greatly speed up the manipulation of the Orsat, one pass being as effective as two passes of the ordinary pipette. With the three-way cock on the pipette in the "down" position, the gas is admitted at the bottom of the pipette and bubbles through the absorption liquid. After all of the gas has been drawn into the pipette, the cock is reversed and the gas then leaves the pipette from the top. If the cock is rotated clockwise, the regular sequence will automatically follow, and it will not be necessary to inspect the position of the cock when turning it from either of the off positions.

The bubbling pipette can be sealed and used with a bellows bag, or water seal, in order to prevent oxygen absorption from the air. With ordinary manipulation of this pipette, a slight error may be introduced because of the residual gas in the downcomer tube. This error can be neglected in boiler-room work. For very precise work, an extra turn of the three-way cock will discharge the small amount of residual gas.

Because of the bubbling feature, this type of pipette can be used with low viscosity reagents, such as[1] "an alkaline solution of sodium hydrosulfite containing 2 per cent of anthraquinone-β-sulfonic acid as a catalyst," which are not satisfactory in the ordinary form of pipette.

M. S. GEREND.

Powell River, B. C.

Heating Water with Exhaust Steam

A layout of exhaust-steam piping that was adopted in a certain shop for heating a large quantity of water for manufacturing purposes is illustrated in Fig. 1. The exhaust pipe, as connected to the engine, was 8-in. and it was continued at that size to the tee *A*. An automatic back-pressure valve should have been installed

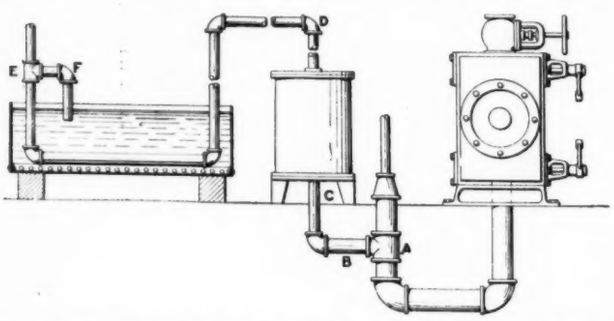


Fig. 1—Arrangement of engine exhaust and heating coil

at this point, but a reducing coupling was used instead. This reduced the outlet to 3 in. in diameter, which of course forced much of the steam to the feed-water heater shown. The pipe line was reduced to 6-in. at *B* and to 4-in. at *C*. Above the heater the 4-in. pipe extended vertically 8 ft. and was then carried over to the tank and dropped down to the bottom as shown, the run of 4-in. pipe being in all about 200 ft. in length. Water resulting from the condensation of the steam is raised to *E* and flows back into the tank at *F*.

This is an economical arrangement so far as outward appearances are concerned, but investigation shows it to be defective. The arrangement of the piping causes a back pressure of 8 lb. on the engine, therefore considerable power is expended in raising the water to the point *E*. As the engine was heavily loaded, this was an objection.

Improvements are suggested as follows: The feed-water heater should be located on the other riser. By making the pipe at *C* and *D* 6-in. and carrying it at

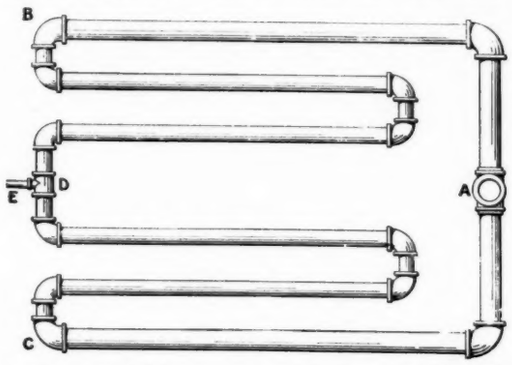


Fig. 2—Suggested improvement in layout of heating coil

this size to the bottom of the tank, steam would flow through it easily and discharge into the 5x5x6-in. tee *A*, Fig. 2. The pipe could be carried at 5-in. to the points *B* and *C*, then reduced to 4-in. and continued to the 4x4x1½-in. tee at *D*.

All the piping shown in Fig. 2 is at the bottom of the tank. The outlet *E* is carried through the side of the tank and connected to a pump that is regulated by an automatic valve. This pump discharges to the boilers, thus saving all the water, and there is practically no back pressure on the engine.

W. H. WAKEMAN.

New Haven, Conn.

Some Pointers on Pipe-Flange Bolts

In steam plants, the breaking of bolts or studs in flanges is a frequent source of annoyance. There are many causes for bolts breaking, the most important being the age of the bolt and the quality of the metal. It seems in some valve-bonnet flanges, that the bolts practically fall apart after 15 to 20 years of service, yet the plant is operated with 200 to 300-lb. steam pressure on the pipe line and the flange bolts are not changed until they break or the joint leaks, or when it is necessary to make some change in the pipe line.

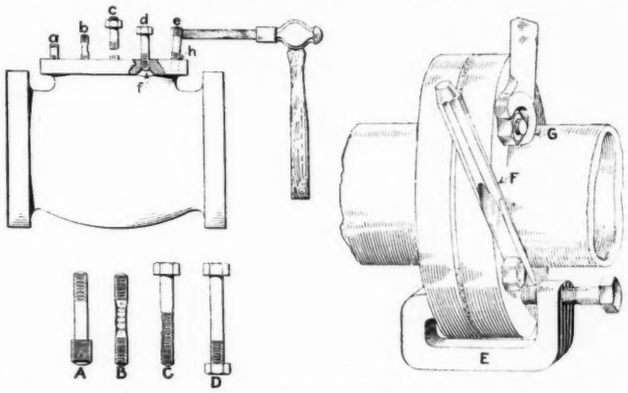
In the figure a globe valve that has been in service for eighteen years is shown with the bonnet removed. The stud bolt *a* broke off even with the bonnet when an attempt was made to remove the nut. The bolt *b* which was on the lower side of the valve, was badly corroded and when scraped, was found to be about half its original diameter. The bolt *c* broke off at the face of the flange, the nut being a tight fit had frozen on and with ordinary strain on the wrench, twisted off the bolt instead of loosening. The bolt *d* is a tap bolt which some predecessor had substituted for a stud bolt without taking the precaution to make it the proper length, with the result that when the bolt was drawn up the back of the flange came out as at *f*.

It occasionally happens when holes are drilled in flanges of valve bonnets, the drill is not set perfectly at right angles to the face of the flange, and when a

[1] This new reagent for oxygen was discussed on page 140 of the July 22, 1924, issue of *Power*.

stud bolt is screwed in it points inward or outward as at *e*. To straighten such bolts, the mechanic doing the work will generally use a wooden block, and hammer the bolt back to its proper position. A bolt straightened in this manner will invariably be defective, as the metal has been fractured at the point *h* and the bolt may break while in service. The method for correcting this should have been, to drill and tap a larger hole at right angles to the face of the flange and use a larger bolt. In some cases, however, a larger bolt could not be used in the bonnet flange as the larger nut would fit too close to the yoke. To meet this condition, a bolt turned down to the required size as illustrated at *A* might be used. At *B* is shown a standard stud bolt, having flaws in the center, as if stretched and on which a pipe wrench had been used to excess, causing much of the metal to be cut away.

The illustration, at the right of the figure, shows a flanged pipe joint in which the gasket fits inside of the bolt circle. The flange had been leaking and there was little chance of putting in a new gasket without shutting down the plant, so we decided to draw the bolts up



Illustrates some flange-bolt breakages and how bolts were renewed with pressure on the line.

tight until such time as the plant could be shut down. Before attempting to do this, however, two clamps, one of which is illustrated at *E*, were put on and one by one the bolts were taken out, the threads cleaned and oiled and put back in place. In many cases it is not easy to get a wrench on the head of a bolt, to hold it from turning, and steam fitters often drive a cold chisel as at *F* between the head of the bolt and the pipe to hold it from turning while loosening the nut. This practice tends to fracture the metal under the bolt head and leaves the bolt defective.

Another cause of flange bolts breaking is the careless use of the open end wrench. Jamming the large side of the wrench between the nut and the pipe as at *G* causes fracture of the bolt at the base of the thread. In some cases I have noticed splits about 1 in. long in the center portion of the bolts, as if the metal had not been welded together properly when rolling, or having been split by twisting when the bolt was tightened up. In some cases the broken bolts seemed soft and showed no sign of crystallization, while in other cases the threads stripped off as if there was little ductility in the metal.

In large power plants using high steam pressure and superheated-steam, the question of quality or tensile strength of flange bolts is becoming an important study. There are many things to be considered: Probably the most important is, the effect of expansion and contraction. When the pipe line is made up, it is cold and the bolts are drawn up tight which puts a tension stress on them. Then the temperature expands both the flange and bolts, and the bolts must have enough elasticity to elongate without exceeding their elastic limit or they become "set" in the stretched condition and do not contract again when the pipe line cools off, consequently when the steam is turned on again the joint will leak. There are now available special flange and stud bolts of chrome nickel heat-treated alloy steel having a tensile strength of 140,000 lb. per sq.in., an elastic limit of 100,000 lb. per sq.in. and an elongation of 16 per cent, which allows for expansion and contraction without permanent set.

Inasmuch as flange and stud bolts appear to lose their elastic limit after several years of service, it seems to me that new bolts should be put in all flanges at intervals of say ten to fifteen years as a precaution against failure of a pipe line at the flanged joints.

Cambridge, Mass. R. A. CULTRA.

A Process of Mechanically Peening Piston Rings To Obtain a Perfect Fit

Probably no subject is more vital to motive power than the adaptability and functioning of piston rings. The necessity of having rings contain their own tension in one case, or the use of auxiliary springs in another, has been the principal cause of lack of satisfaction in their uses.

In the construction of split rings it has been customary to make them larger in diameter than the bore of the cylinder and cut out sufficient in the split for clearance; thus, when rings are sprung into the cylinder, the circular arcs of the rings do not correspond with those of the cylinder bore, so an attempt is made to overcome this by closing the rings to their running position for final diameter, and even then there will be greater pressure at the ends than elsewhere.

Many years ago the foregoing conditions were found so detrimental that after much experimenting I constructed a machine for mechanically peening the inner surface of rings to supply the tension lost through constant use, and with proper methods applied, it became possible to obtain a perfect fit with uniform tension of the rings to the cylinder walls.

For the benefit of anyone who may wish to try the process temporarily by using the edge of a hammer for peening the rings, the following explanation is submitted:

Place the ring in the cylinder at the position it is to travel, then lightly tap the inside of the ring with a small hammer and mark with chalk every spot that sounds solid (other places will vibrate), remove the ring and place it on a hardwood block and peen the surfaces chalked, continuing this operation until the ring has no vibration or rattle when lightly tapped with a hammer when in position in the cylinder.

New rings that are to be expanded and fitted should be turned to the diameter of the cylinder and diagonally split with a hack-saw; then after being mechanically peened and fitted as described there will be a uniform tension against the walls of the cylinder.

During more than twenty years I have known this process to be in constant use on engines of nearly every type with no known breakage. The machine referred to is constructed with adjustable knurled rolls to give a pressure contact instead of a blow.

Paterson, N. J. BURTON S. COWLES.

Comments from Readers

Reading vs. Filing

Referring to the Foreword in the Sept. 23 issue on "Reading vs. Filing," I should like to make a few comments.

Some fourteen years ago I contracted my case of "enfilitis," contracting it from Prof. C. A. Adams. I thoroughly agree that the filing habit may degenerate into a mere collection of unread paper. The treatment for this situation is to insert between the clipping and filing a third and, as pointed out in the Foreword, the most important step, that of reading. My own practice is to allow the clippings to accumulate, reading them as opportunity permits. I find a handful of these clipppings good company to take along with me on a railway trip.

A tip I would like now to pass along to my fellow clippers is that a safety-razor blade makes a fine tool for neatly and rapidly removing a clipping from a magazine.

L. A. DOGGETT,
Assoc. Prof. Electrical Engineering,
State College, Pa. Pennsylvania State College.

Single vs. Two-Pass Condensers

In *Power* of Sept. 30, page 546, Frank R. Wheeler, commenting on my article on single-pass condensers published in the issue of Sept. 2, intimates that the conclusions are based on isolated tests which are not representative, and which are "the poorest of nine."

I refer those interested to my original article and the original Navy tests as reported in the Journal of the American Society of Naval Engineers of November, 1922.

Mr. Wheeler maintains that the two-phase design is more conservative, offers a better vacuum and a greater factor of safety in heat transfer. He presents in support of these claims certain tests and comparisons of the bids of two makers of the respective types in a recent letting. I quote below the figures for the two-pass condenser as given by him.

FIGURES FOR TWO-PASS CONDENSER

Pounds steam per hr. to be condensed	175,000
Square feet cooling surface	27,000
Number of tubes	5,160
Size of tubes, in., 20-ft. long	1
Gallons per minute	36,000
Horsepower for pumps	114
Vacuum, in. mercury at 55 deg.	29.24
Heat transfer B.t.u.	440

Mr. Wheeler has added the last item, the heat-transfer co-efficient which was not included in the customer's tabulation. To meet the guaranteed performance this would have to be 593 instead of 440, as can be readily calculated from the amount of heat to be transmitted, the square footage and the mean temperature difference.

Mr. Wheeler does not state his ideas of conservatism in any definite terms but implies that his margin is very large. A 10-per-cent allowance would call for test results under the same conditions showing a 650-deg. co-efficient and a 20-per cent allowance test showing a co-efficient of 710 when bidding on a 593 transfer.

A reference to the bids will show that in connection with the vacuum guarantee a tolerance of 0.1 in. was stated. Subtracting 0.1 from the vacuum of 29.24 in. gives 29.14 in., and at this vacuum I figure the co-efficient to be 426. This would seem to be the conditions at which Mr. Wheeler figured his 440 co-efficient. But Mr. Wheeler presented the vacuum of 29.24 as an example of high performance conservatively calculated and therefore should show the corresponding co-efficient of 593 and define the conservatism in that figure.

New York City. PAUL BANCEL.

The Protection of Pressure Gages

I was much interested in the article by Mr. Booker in the Sept. 9 issue entitled, "The Protection of Pressure Gages."

Some years ago I had charge of several hydraulic presses on which the pressures ranged from 500 to 5,000-lb. gage. On some of the presses the pressure was raised every few minutes, and the release made in a few seconds. The gages were connected at the pumps with an upright pipe, no shock absorbing device being used. I did not encounter one case where the accuracy of the gage was destroyed in a few hours, as stated in the article, so long as the press was operated in the regular way. After several years experience with this equipment, I am convinced that proper gages will remain accurate for many months if the pressure is raised slowly, say in from two to four minutes. The sudden release of pressure appeared to have no detrimental effect upon the accuracy of the gage.

In one case when a pressure of 1,000 lb. was suddenly thrown on, the accuracy of the gage was seriously affected. It was not known what pressure had been transmitted to the gage, as the pointer jumped to the stop at the 5,000-lb. mark, at the instant when the 1,000-lb. pressure was accidentally thrown on.

In most cases where gages are used in hydraulic work sufficient air will collect in the gage connections to serve as a protection to the mechanism of the gage.

Toronto, Ont., Canada. JAMES E. NOBLE.

The Salesman Who Becomes a Nuisance

Like many other engineers, I receive frequent visits from salesmen. Some of these I enjoy and often when not able to give them business, have given them hints as to where it might be obtained. There is, however, one type of salesman that if I see him at all is sure to leave without an order. I refer to the type, perhaps best known as fault finders. It does not matter what you are using in their particular line you are in their opinion "robbing your employer." One man of this type called on me a few days ago. He was representing a coal firm and was most emphatic in his statement that he could make a substantial reduction in my weekly fuel

bill, although he was quite unaware of the kind of coal we were using. He became quite annoyed because I would not place a trial order for fifty tons. There are several men of this type traveling around today, and how they manage to do business, and justify their position, is something I cannot understand.

Most salesmen of this type overlook the fact that to call down a rival's goods, that I may be using, is questioning my judgment, which, naturally, lessens their chance of getting an order from me. Of course, all travelers are not of this pattern, and I recall one old gentleman who calls on me occasionally. For a long time he called regularly before the account was opened, which in the end was brought about partially because of another firm's neglect, and never during these visits did he say one word against any other firm's goods. I remember on one occasion, trying him out in this direction, only to be told that he didn't know anything bad about any firm but plenty of good about his own. On several occasions, he has given me valuable advice on many matters in no way connected with his firm, but which made for their benefit, and a friendship was formed that increases as time goes on.

With competition as it is today no firm can afford to employ a salesman of the type first mentioned. In one journey he can break down a friendship that has taken years of hard work to build up. Some firms, I am sure, fully realize this, but that there are others who do not is apparent, otherwise we would not have to waste valuable time getting their salesmen off the premises. Although I am a consistent believer in advertising, an unsuitable salesman can, in my opinion, prevent much of this being as effective as it would be if he were out of the way, and the power-plant man left to his own judgment.

F. P. TERRY.

Belfast, Ireland.

Loss Due to Combustible in the Ash

In reading the article by Mr. E. Ogur in the Sept. 9 issue, entitled "Burning Anthracite in a Modern Steam Plant" it occurred to me that perhaps part of my experience along that line might be of interest.

In good boiler-room practice, the percentage of combustible in the ash will vary widely with the character of the fuel used, the type of stoker installed, and the rate of firing the boiler. In other words the percentage of combustible in the ash that gives the best boiler and furnace efficiency is controlled by conditions which may vary in different plants.

The amount of combustible in the ash can generally be reduced by one of the following methods: (a) By carrying a lighter fire. (b) By reducing the speed of the traveling grate in a chain grate stoker. (c) By burning down for a longer period in a hand-fired furnace or in a stoker installation with dumping grates. (d) By admitting more air through the ash in the clinker pit in stokers using a clinker grinder. Any of the above methods, if carried beyond a certain limit, will increase the stack loss and decrease the steaming capacity of the boilers.

Therefore, in order to secure the maximum boiler and furnace efficiency, the boilers should be so operated that the sum of the ash-pit loss plus the stack loss is the lowest possible, except in instances where it is necessary to sacrifice efficiency to secure a high rating.

I have had considerable operating experience in large power plants in the East, equipped with underfeed stokers and burning a good grade of Pennsylvania bituminous coal. In these plants it was found that the maximum efficiency was obtained with from 25 to 40 per cent excess air and when the combustible in the ash ran around 15 to 20 per cent.

In my experience with chain grate stokers burning Illinois and Indiana screenings, I found that the combustible in the ash could not be reduced below 20 per cent without seriously increasing the loss due to excess air and that the maximum efficiency was obtained when the combustible in the ash averaged around 25 per cent. However, high per cent combustible in the ash does not necessarily mean an inefficient plant.

Some time ago, I visited a large power plant, in the Pittsburgh district, burning West Virginia coal containing about 8 per cent ash. The combustible in the ash was running 30 to 35 per cent. To the layman this would appear to be a great waste of coal. However, the actual loss is not very great.

Assuming that the percentage of combustible in the ash was 33⅓ per cent, the percentage of coal that is wasted as combustible in the ash equals: $\frac{0.08 \times 0.333}{0.666}$ = 0.04 per cent, and the loss due to the combustible in ash equals: $\frac{0.044 \times 1.00}{1.00 - 0.08}$ = 0.043 or 4.3 per cent.

The average efficiency of the boilers in this installation was approximately 78 per cent which gives a total loss of 100 — 78 = 22 per cent. Assuming that the loss due to radiation, sensible heat in the ash, etc., was 5 per cent, the loss up the stack then would be:

0.22 — (0.043 + 0.05) = 0.127 or 12.7 per cent.

Although I believe that the combustible in the ash should have been kept as low as 20 per cent in this particular installation, to have accomplished this would have considerably increased the loss due to excess air. In this case, if the combustible in the ash averaged 20 per cent, the loss would have been reduced to 2.13 per cent, but the increase in boiler efficiency would have been much less, due to increased stack loss.

In one installation with which I am familiar the stokers are equipped with side plates through which no air is admitted. The stokers are cleaned by hand. At the first cleaning the rake is used and only the large clinkers are removed. At the next cleaning the hoe is used and all refuse on the dead plates is removed. Due to the fact that no air enters through the dead plates, this method does not increase the percentage of excess air. It does, however, limit the boiler capacity to some extent.

Previous to putting this system of alternate cleaning into operation, the following monthly averages were obtained: Combustible in the ash 18.12 per cent, efficiency of boiler furnace and grate 65.9. After using this method of cleaning these figures were changed to 6.18 and 68.95 respectively.

A change to a poorer grade of coal while using the alternate method of cleaning, gave the following results: Combustible in the ash 11.62 per cent; efficiency of boiler, furnace and grate 69.2 per cent, which is a considerable improvement over the results previously obtained.

It might be mentioned that the low efficiency obtained is due to the type of boiler and setting. The combustion chamber is small and the boiler is a single-pass with a horizontal baffle, which causes a high stack temperature.

GEO. E. GASTER.

Tyrone, Pa.

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Higher Thermal Efficiency from Lean Mixture

Why does a lean mixture in an internal-combustion engine give a higher thermal efficiency than a richer mixture? *M. S. T.*

Considering the Otto or constant-volume-cycle engine, the thermal efficiency is $E = 1 - \frac{1}{r^{K-1}}$, where r = ratio of initial, or suction volume to the final, or compression, volume, and K is the ratio of the specific heats at constant pressure and constant volume. In an existing engine r, the volume ratio, is fixed and the only variable is the specific heat ratio K.

If nothing but pure air was in the cylinder, K would be 1.408. Gases or gasoline vapors have a lower specific heat ratio, and as the mixture gets richer, K for the entire mass decreases and the fraction $\frac{1}{r^{K-1}}$ becomes larger, making the efficiency lower. The leaner the mixture the nearer K approaches 1.408 and the greater is the thermal efficiency.

Viewed in another way, C_p the specific heat at constant pressure is made up of the specific heat at constant volume plus the work done or C_p = Work + C_v. To make the ratio $\frac{C_p}{C_v}$ large C_v must be small for a given heat addition. This means that upon ignition of a charge containing a given amount of heat the maximum temperature will be higher, since the B.t.u. added per degree is small, that is, C_v is small. In expansion the steepness of the curve is proportional to K, or with a small C_v the curve will be steep and the final exhaust temperature will be low. The temperature drop will then be greater than with a more gradual curvature of the expansion line. Since the efficiency depends upon the maximum and exhaust temperatures, the efficiency is greatest with K approaching 1.408, or where a lean mixture is used.

Settling of Front Ends of H. R. T. Boilers

In case two horizontal return-tubular boilers set in battery have settled about two inches on their front ends, where should we look for the source of the trouble and how can the defect be remedied? *J. C.*

If the boilers are suspended from beams that rest on columns, by the method commonly known as the suspended type of setting, lowering of the boilers probably would be chargeable to settling of the foundations of the columns. If satisfied that the settling will go no farther, the boilers may be disconnected from piping, and after they are blocked up, the hangers can be taken up or provided with thicker straps for taking their bearings on the crossbeams, or the beams may be raised and given bearings on iron plates of proper thickness for supports on the columns. If the boilers are supported by side brackets that rest on the walls of the setting and the foundations have settled apparently as far as they are likely to go, the boilers can be blocked up high enough to build up the side walls so that wall plates will receive the boiler brackets to give the right height for the boilers. If settling at the foundations continues, the only remedy is to obtain broader and deeper foundations. If the boilers are supported by brackets that rest on the side walls and there is no settling of the foundations, the trouble probably would be due to ravelling and crushing of the walls from movement and the weight received from the brackets near the front ends of the boilers. This trouble is most likely to affect the partition wall. The condition is readily inspected by removing the brickwork above the wall plates supporting the front brackets and might be caused by dependence on rigidity of these supports without good rollers and stiff wall plates under rear end brackets; or by not having sufficient clearances and suitable expansion joints in the brickwork to permit of endwise expansion and contraction of the boiler without reacting as a drag on the front end brackets, with disintegration of the supporting walls. For making repairs to the setting, disconnect piping, block up the boiler high enough to remove the brickwork that has become disturbed and rebuild the walls to the proper height to receive stiff wall plates of good length for supporting the boiler brackets. The other wall brackets, plates and rollers should be examined and, after the boiler is let down, make careful inspection to see that all brackets take good bearings and that expansion and contraction of the boiler may take place without disturbing the positions of the brackets nearest the front ends of the boilers.

Selection of Indicator Springs

How is selection made of the proper scale of springs to be used in an indicator on a triple-expansion engine with the following initial pressures: High-pressure cylinder, 135 lb. gage; low-pressure cylinder, 23 lb. gage; low-pressure cylinder, initial 0 or 1 in. vacuum, with 24 in. vacuum on exhaust? *F. J. B.*

The number stamped on the spring represents the number of pounds pressure to the square inch required to compress or elongate the spring sufficiently to move the pencil vertically 1 in. on the diagram. The strength of spring employed should be such that the highest or lowest pressure to which it is subjected will be indicated by as much height of diagram as possible, but approximately ½ in. less than the range of action of the

pencil motion above or below an atmospheric line made with the spring in the indicator. For most indicators the working range with the spring in the indicator is about 1¾ in. above the atmospheric line for pressures above the atmosphere and about 1 in. below for pressures below the atmosphere. Hence, to find the scale of spring to be used for pressures above the atmosphere, divide the pressure by 1¾, or use the next higher scale of spring available; and for pressures below the pressure of the atmosphere use the scale of spring corresponding to the lowest pressure, pounds per square inch to be indicated below the pressure of the atmosphere.

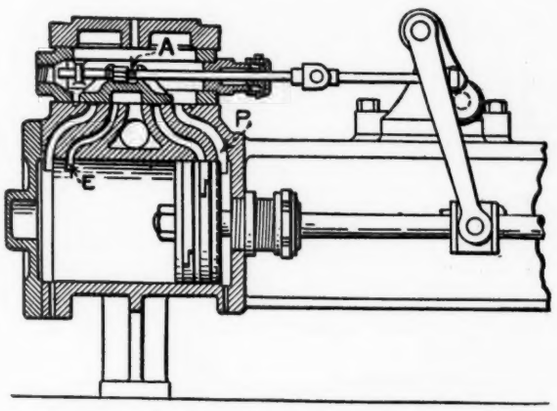
Having 135 lb. gage initial pressure for the high-pressure cylinder, the strength of spring to give a diagram 1¾ in. above the atmospheric line would be 135 ÷ 1¾ = 77, hence preferably use an 80 spring, giving 135 ÷ 80 = about 1.7 in.; for the intermediate cylinder with 23 lb. gage initial pressure, the scale of spring should be 23 ÷ 1¾ = 13, hence use a 16 spring giving 23 ÷ 16 = about 1.4 in., or a 20 spring giving 23 ÷ 20 = about 1.1 in. For the low-pressure cylinder with 24 in. vacuum, the lowest pressure to be indicated would be 24 × 0.49 = about 12 lb. per sq.in. below the atmosphere and a spring whose scale is 12 would be suitable. If a spring is used whose scale is 16, the lowest pressure would be indicated 12 ÷ 16 = ¾ in. below the atmospheric line; or using a spring whose scale is 20, the lowest pressure indicated would be only 12 ÷ 20 = 0.6 in. below the atmospheric line of the diagram made with the spring in the indicator.

Lost Motion of Steam Valves of Duplex Pump

What is the purpose of having lost motion between the steam valves and valve rods of a duplex pump?
G. A. W.

It should be borne in mind that the steam valve of one side of the pump is operated from the piston rod of the other side. The steam valves are similar to those of plain D slide-valve engines, but they do not lap over the steam or exhaust ports when the valve is in the middle of its travel. When a valve has no lap on either the steam or exhaust sides, it closes the exhaust at the same time it opens the admission, and for a pump such a valve would have to act quickly at the end of the stroke. This would not be desirable in a duplex pump where the valve on one side is operated from the piston rod on the other, as the pistons would have to reach the ends of their strokes at the same time and there would be danger of the pump's stopping "on center." To avoid this difficulty the valves are given considerable lost motion by allowing enough clearance or lost motion between the valve and its rod. This permits the valve to remain stationary until the piston has nearly completed its stroke and renders it impossible for the pistons to stop on centers, as they do not arrive at their extreme positions at the same time. Therefore, one of them is always in position to be moved by the steam.

The illustration shows a longitudinal section of one cylinder and steam valve of a duplex pump with the piston beginning a stroke toward the head end of the cylinder. The valve has been moved forward by the piston rod of the other side of the pump so as to admit steam behind the piston and open the exhaust from the head end of the cylinder. As the piston moves forward the valve remains stationary, due to the lost motion *A* between the valve and its rod. When the piston is nearly at the end of its stroke, the piston rod of the other side of the pump begins to move the valve backward, closing the admission port *P* and exhaust port *E*. By this time the piston has covered the exhaust port on the head end of the cylinder and compresses the steam in the end of the cylinder, thus stopping the piston gradually. By the time the piston has reached the end of the stroke, the lost motion is taken up and the valve has been moved back far enough



Steam cylinder and valve of duplex pump

to uncover the admission port on the head end and open the exhaust port on the other end of the cylinder, and the piston starts on its return stroke. Hence the lost motion not only prevents the pump from stopping on a center, but also is advantageous in permitting the pump pistons to pause at the ends of their strokes, thus giving the water valves time to seat quietly.

Cost of Elbows in Exhaust Pipe

What would be the effect on the economy of an engine to remove four elbows from a six-inch exhaust pipe that discharges to the atmosphere. The length of exhaust line is 125 ft. and back pressure due to the exhaust line is 4 lb. gage? *E. C.*

Each 6 in. elbow causes the same back pressure as about 25 ft. of 6 in. pipe. If the present back pressure due to 125 ft. of exhaust pipe with four elbows is 4 lb., there would be the same back pressure due to a straight pipe (25 × 4) + 125 = 225 ft. long and, by removing the elbows, the back pressure due to the exhaust line would be $\frac{125}{225}$ of 4 or about 2 lb. and cause approximately the same reduction of back pressure on the piston of the engine. Then the steam required would be substantially the same as for a load requiring 2 lb. less m.e.p. and for small differences of load the steam consumption may be regarded as in proportion to the m.e.p. That is, if the load requires 55 lb. m.e.p., the removal of 2 lb. back pressure would reduce the steam consumption $\frac{2}{55}$ or between 3 and 4 per cent.

[Correspondents sending us inquiries, should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Here and There in the Power Plant

Sidelights on things generally used but less generally understood

Loss of Combustible in the Ash

WHEN an engineer is presented with data on the composition of the coal and the percentage of combustible in the furnace refuse, he is sometimes a little confused when it comes to combining the two to get the actual loss of combustible.

In cases like this it is generally better to reason out just what must be happening than to apply some formula blindly.

For the purposes of this study, coal may be looked upon as consisting of three substances only—ash, combustible and moisture. What happens to these when the coal is burned? Obviously the moisture goes up the stack. It certainly cannot remain in the hot refuse.[1] For the ash there are two possible avenues of escape, the most obvious being the ash pit. It is often assumed that all the ash goes into the refuse. As a matter of fact part of it escapes up the stack, although the amount so escaping may be negligible in the case of a hand-fired boiler operating on natural draft.

Some Ash May Be Carried Up the Stack

Where coal containing a large percentage of fines is burned at a high rate with forced draft, as is frequently the case in modern stations, a substantial portion of the ash may be carried up the stack in the form of cinders and small dust. Where cinder catchers are used, the trapped cinders may be mixed with the ash-pit refuse before weighing and analyzing the refuse for test purposes. Unless electrostatic dust precipitators[2] are used the fine ash dust escapes up the stack.

With powdered coal it is to be expected that a large percentage of the ash will pass up the stack, but the manufacturers of powdered fuel apparatus claim that stoker-fired boilers, operating at high ratings, do not lag far behind in this respect.

Tracing the Fuel Through Furnace to Stack and Ashpit

Ordinary computations for loss of combustible in the ash are usually made on the assumption that none of the ash goes up the stack. Assuming for the moment that this is the case, it is interesting to trace the ingredients of the coal in their journey through the furnace.

[1] Throughout the present article the term "ash" will be used in its chemical sense to mean all the non-combustible solid material in the coal. The material in the furnace ashpit—consisting partly of ash and partly of combustible material—will be called "refuse."

[2] An experimental installation of this sort has been installed in the new station at Trenton Channel.

The following analysis is given by the Bureau of Mines for a certain coal from the Pittsburgh district:

	Per Cent
Moisture	5.13
Volatile	27.87
Fixed carbon	58.29
Ash	8.71
Total	100.00

Heat per pound as fired, 13,365 B.t.u.

For the purpose at hand, this analysis may be rewritten as follows:

	Per Cent
Moisture	5.13
Combustible	86.16
Ash	8.71
Total	100.00

A chemist might object that the 86.16 per cent of so-called "combustible" contains some non-combustible nitrogen, but as the total nitrogen in the coal is generally less than 1.5 per cent, this correction is not of practical importance.

Now suppose this coal were burned by some superhuman fireman in such a way that not a speck of combustible material found its way to the ash pit. Under such conditions 8.71 lb. of refuse would be removed for every 100 lb. of coal burned. The other 91.29 lb. would go up the stack in the products of combustion. The analysis of the refuse would, of course, show it to be free from combustible and moisture. It would be pure chemical ash.

Case of Combustible in Refuse

Next, take an actual case where some fines get down through the grate and the refuse carried into the ash pit is not completely burned. Suppose so much of this falls through that the total amount of refuse is doubled, giving $8.71 \times 2 = 17.42$ lb. of refuse for each 100 lb. of coal fired. This 17.42 lb. must contain exactly 8.71 lb. of ash. In other words, the refuse analysis will show exactly 50 per cent ash, the other 50 per cent being combustible. In this case one might conclude that 8.71 per cent of the fuel is wasted through the grate. While somewhere near the truth, such a conclusion would not be exact. The 8.71 lb. of combustible material is not the same as raw coal.

A second approximation to the truth is obtained by assuming that the combustible in the ash has the same analysis and the same heating value as the combustible in the coal. The combustible in this coal has a heating value of $13,365 \div 0.8616 = 15,512$ B.t.u. per pound. The logic of this computation is that all of the 13,365 B.t.u. in one pound of coal as fired, must necessarily reside in the 0.8616 lb. which is combustible, so that the heat per pound in this combustible portion must be equal to the total heat in a pound of coal divided by the weight of the combustible portion.

Assuming that the combustible in the refuse has the same composition as that in the coal, the 0.0871 lb. of combustible lost from each pound of coal fired represents a heat loss of $0.0871 \times 15,512 = 1,352$ B.t.u., which is $100 \times 1,352 \div 13,365 = 10.12$ per cent of the heat in the coal as fired.

Practically No Volatile in the Refuse

However, the common assumption that the combustible in the refuse is like that in the coal fired is hardly more logical than the assumption that the combustible material in the ash is just plain coal.

The assumption that it is plain coal gives too low a value for the heat loss while too high a value for the loss is always obtained by assuming that the combustible in the refuse is the same as that in the coal.

It would seem nearer the truth to say that the combustible in the refuse is pure carbon with a heating value of 14,600 B.t.u. per pound. Pound for pound the volatile portion of the coal always has a higher heating value than the fixed carbon. This volatile matter is quickly gasified at furnace temperatures and is entirely eliminated from any coal that stays in the furnace for an appreciable period. Only those particles or lumps of coal that fall through the grate soon after being fired, and land in a comparatively cool section of the ash pit can retain their volatile constituent.

Not only is the assumption that the ash pit combustible is pure carbon more logical but it also simplifies the computations. In the case under consideration the loss would be figured as $0.0871 \times 14,600 = 1,272$ B.t.u. per pound of coal, or $100 \times 1,272 \div 13,365 = 9.54$ per cent of the heat in the fuel as fired.

Figuring Combustible Loss

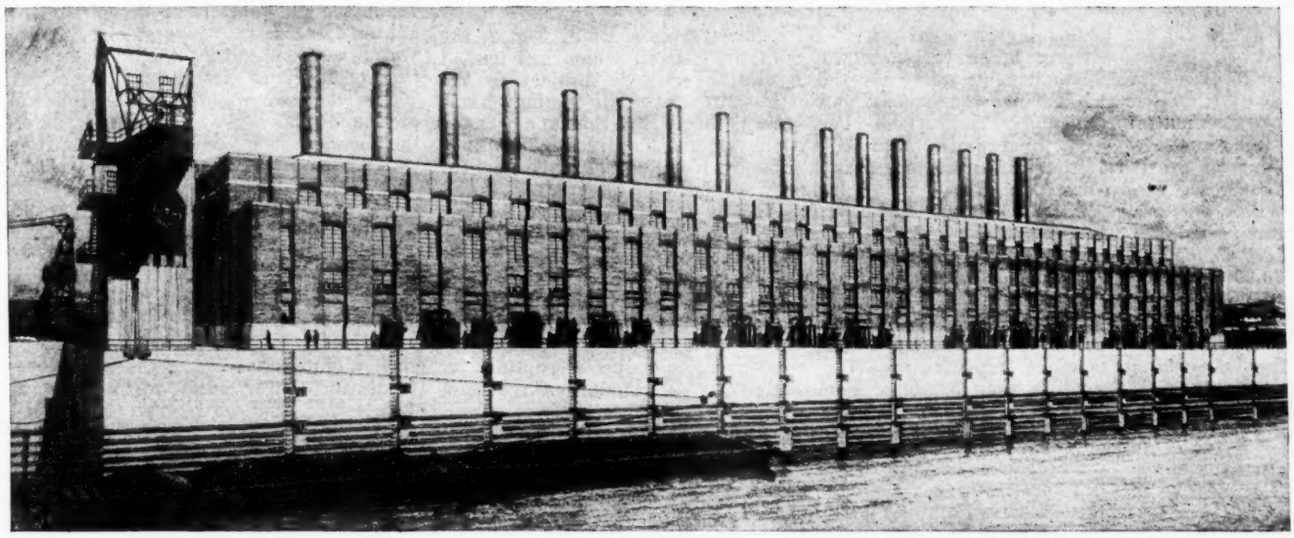
It has not yet been made clear (except for one case) how the percentage of combustible lost is figured from the percentage in the refuse.

This can best be explained by an example: Suppose the refuse shows 30 per cent combustible and 70 per cent ash, the coal analysis being that already given. If 100 parts of coal are fired, 8.71 parts of the coal form 70 per cent of the refuse. The total refuse from 100 parts of coal will then be

$$\frac{8.71}{0.70} = 12.45 \text{ parts.}$$

Of this 12.45 — 8.71 = 3.74 parts is combustible. Hence the weight of combustible lost is 3.74 per cent of the weight of coal fired.

First Section of Toronto Plant Nears Completion



Architect's sketch of ultimate plant. Present development is represented by the four stacks at the left

ACCORDING to present indications, the first section of the new Toronto station of the Ohio River Edison Company will be ready to take on load in January, 1925. Located on the Ohio River, about nine miles from Steubenville, Ohio, this station is designed for an ultimate capacity of 264,000 kw. The first section will contain 66,000 kw. in two units.

The Toronto station, which was designed by Stevens & Wood, engineers, embodies several original features, chief of which are the box construction of the substructure, a ventilating system scientifically planned to recover all the waste heat in the plant and a novel arrangement for heat balance.

While automatic centralized combustion control has already been installed in a number of old plants, Toronto is one of the first of the large new stations to be so equipped.

Watertight Box Construction

The Ohio, like most Midwestern rivers, is subject to extreme variations in water level, the maximum from flood to dead low being 46 ft. This necessitates the location of the circulating pumps, and preferably the condensers as well, considerably below the high-water level. It has hitherto been the custom to handle this situation by the use of watertight condenser pits. At the Toronto site the existence of hardpan at a convenient level for the construction of a continuous concrete mat without piles made it feasible to construct the substructure as a single reinforced-concrete box extending from the firm bottom to the turbine level two feet above the highest known flood level.

This construction avoids a long exhaust connection to the condenser, while eliminating the possibility of any barometric break in the circulating water. In addition, full use is obtained of the basement as an operating floor and the height of the superstructure is reduced about thirty-six feet. With all these advantages this construction has proved no more expensive than the customary "condenser pit" arrangement.

The whole substructure is largely of cellular construction to stiffen the bottom and side walls, the cells being utilized for ash sumps, oil rooms, etc.

In the present installation coal is handled from barges by a tower of 250 tons hourly capacity, cableway and conveyors being provided for stocking and reclaiming. After pulverization in three 15-ton, 6-roll mills the fuel passes to a 90-ton reinforced-concrete bunker and thence to the burners, of which there are twelve on each of the four boilers.

The boilers are of the cross-drum, sectional, water-tube type, and generate steam at 375 lb. and 706 deg. (at normal load). Each contains 22,500 sq.ft. of heating surface, including water screens, and 4,100 sq.ft. of superheating surface. The furnace volume is 13,800 cu.ft.

The unusually high feed temperature (378 deg.) leaving little opportunity for an economizer, a plate-type air heater is used to salvage the sensible heat of the flue gases. Fitting into the ventilating scheme and at the same time recovering the radiation losses about the plant, an individual forced-draft fan on top of each boiler takes air from the top of the boiler and turbine rooms and forces it through the air heater to the furnaces. Each air heater has 120 elements and 11,600 sq.ft. of heating surface.

With water screens on the three sides and bottom of the furnace and air cooling of the side and front walls, the refractories are exceptionally well protected even with preheated air. The induced-draft fans are so placed on top the boilers and directly under the stacks, as to demand a minimum of draft loss and breeching construction.

Following the system successfully employed at the Lowellville Station of the Pennsylvania-Ohio Light & Power Co., complete automatic control of boilers and furnaces is provided, with a central control room for all mechanical functions. The two 33,000-kw. (37,500-kva.) turbo-generators run at 1,800 r.p.m. and generate three-phase, 60-cycle, 11,000-volt current. Each main unit is served by a 50,000-sq.ft. condenser equipped with two 30,000-gal. per min. circulating pumps and two hotwell pumps, all of which are motor driven.

Novel Heat-Balance Arrangement

Several novel features are embodied in the heat-balance system. There is one 1,500-kw. house turbine for each main unit. This house unit, which provides power for all the major auxiliaries, is bled at the constant pressures of 196 lb. (absolute) and 52 lb., and exhausts at 18 lb. By interlacing these bleed points with two on the main unit, together with a third point for the evaporators, several important advantages are realized. No matter what the load, the feed temperature is automatically maintained constant at 378 deg., while the house turbine generates just the power required for the auxiliaries. The plant efficiency is practically the same as if all the auxiliary drive were furnished by the main unit. At the same time the auxiliary service is independent of any outside or main-unit disturbance. The only connection of auxiliary buses to the main line is by the house transformers through limiting reactances. These house transformers take up any slack from the house turbines and act as spares for them.

Another novel feature of the Toronto station is the absence of atmospheric relief valves and piping. Failure of vacuum automatically closes the throttle and primary valves of the turbine. This arrangement not only reduces the cost, but prevents air leakage and eliminates the uncertainty of operation in a very large and infrequently operated valve. The automatic device is set to operate when the vacuum falls to 20 in. As an auxiliary safeguard a special relief diaphragm of lead is provided.

American Condenser Practice

By Francis Hodgkinson*

THERE are a few instances of jet condensers serving large turbines in locations where condensing water is acid bearing so that surface condensers are deemed impracticable. The largest single unit of this kind is at the Warrior Station of the Alabama Power Co., being a low-level, Le Blanc type with a water capacity of 26,000 gal. per min., serving a 30,000-kw. turbine. Surface condensers containing as high as 70,000 sq.ft. of surface in a single shell are in use.

There has been a tendency on the part of all manufacturers to increase the "air-cooling" surface, representing that part of the cooling area between the outlet of the air pump and the point where the condensate is removed. In Westinghouse condensers this represents 8 to 10 per cent of the total surface. The evolution of the design of hotwells is indicated in the figures. At the present time, the deaëration is accomplished in the condenser hotwell with consequent elimination of oxygen.

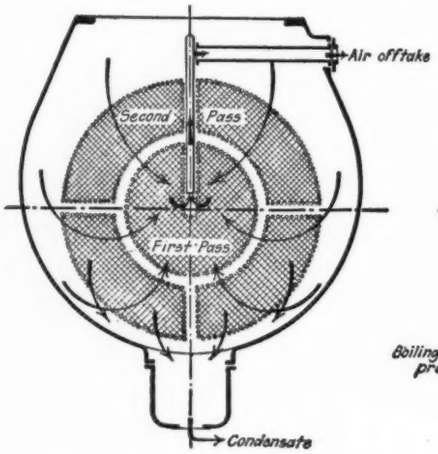


Fig. 1—Radial flow condenser of early design

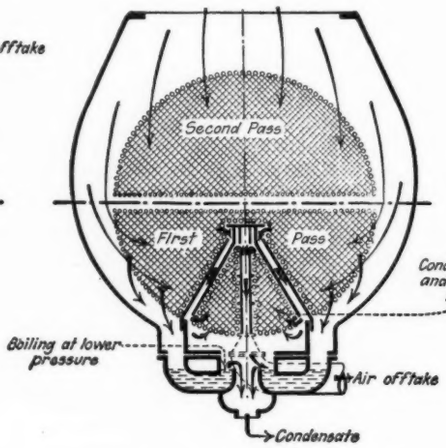


Fig. 2—Boiling in hotwell with partial deaëration

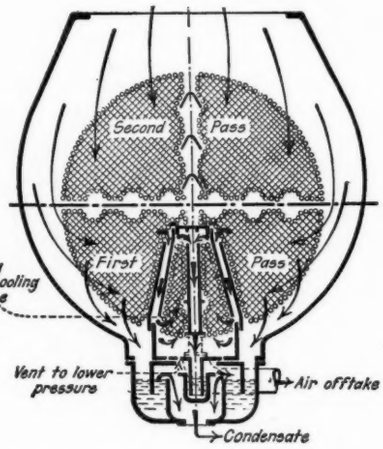


Fig. 3—Special design of hotwell eliminates oxygen

Early Radial Flow Design Discharges Air Upward

In the earlier radial flow condensers, Fig. 1, vapors for the vacuum pump were taken upward while condensate naturally flowed below to the hotwell for outlet. In Fig. 2 air is taken out below the condenser, and is made by baffles to circulate through a definite quantity of tube surface for the purpose of "air-cooling." It will be seen that these vapors come originally from the central part of the condenser. The so-called air-cooling surface is perhaps to some extent misnamed as it may be as effective for condensing steam as any other surface in the condenser so long as the air leakage is at a minimum. Condensate from the bottom of the shell drains outside of the partitions into the hotwell through hydraulic seals, so that it leaves the shell at the temperature of the steam entering the condenser.

With the arrangement of Fig. 2, the water in the hotwell which has passed the hydraulic seals is subject to the lower pressure in the air-cooling chamber. It was discovered that under these conditions violent ebullition or boiling, took place. Hotwells of this general design were built with greater water surface so as to provide a liberating velocity of about 30 ft. per sec. and thus provided effective means of deaëration.

A third type as in Fig. 3, was then evolved with a small vent to the air-cooling surface so as to prevent air binding. The degree of evaporation of the condensate can be regulated to some extent by adjustment of the size of this vent.

Tests at the Windsor station of the West Penn Power Co. and the Ohio Power Co., with a hotwell as in Fig. 2 showed that the water that entered with an oxygen content of 0.28 c.c. per liter could be reduced to 0.041 by means of deaëration.

Intermittent Pump Operation Causes Oxygen in Condensate

A common cause of high oxygen content frequently lies in the intermittent operation of the condensate pump. When excess capacity is present, the pump alternately fills up and then completely evacuates the condenser. During the latter interval the condensate becomes aërated by air from the condenser. Tests in such installations have shown that by throttling the condensate discharge so that the pump has a definite suction head, the intermittent action is stopped. Aëration therefore becomes less and the desirability of employing a hydraulic seal between the condenser shell and the pump is evident.

Tests on condenser tubes at different degrees of cleanliness indicated that the heat transfer in a clean tube is proportional to the square root of the water velocity, while with a foul tube the transfer varies about as the three-tenths power of the velocity. Some manufacturers base guarantees on a condenser performance of 600 B.t.u. per sq.ft. per degree F. per hour with a 6-ft. circulating water velocity. It is customary ordinarily to base performance on guarantees of 400 to 450 B.t.u., using 6 ft. per sec. circulating-water velocity and 70 deg. F. temperature of in-going circulating water.

The maximum elevation of the top of the discharged-water connection to the condenser above the circulating-water supply has frequently been limited to 20 ft. Experience, however, shows that this may be increased to 25 provided the piping is free from air leaks and abrupt changes of direction of flow. The 40,000-sq.ft. condensers at Sherman Creek Station of the United Electric Light & Power Co. have frequently shown 27 in. vacuum by mercury column connected to the top of the circulating water-outlet during periods of low tide, and no operating difficulties were encountered in consequence.

*From paper read at the World Power Conference, July, 1924, in London.

Corrosion of Unlined Stacks

By Frank Burton*

Unlined steel stacks are very commonly used as smokestacks because of the low first cost, but in view of the rapid deterioration of such structures, it is questionable if they are economical. Steel stacks lined with masonry, when properly constructed, are quite permanent, but when unlined the corrosion is rapid. It takes place on the interior of the stack, originates near the top and extends downward.

The generally accepted theory is that when a fire is burning low, the top of the stack is cooled to a point below the boiling point of water, so that there is a condensation of moisture in the products of combustion in the stack. In this water is observed a certain amount of sulphur dioxide arising from the sulphur in the coal, and in contact with oxygen some of it is converted into sulphuric acid with a formation of ferrous sulphate. This in time oxidizes to ferric sulphate and ferric hydroxide, and the ferric sulphate in turn is reduced to ferrous sulphate by the iron and then oxidizes again.

In consequence of this property of

*Commissioner of Buildings and Safety Engineering, City of Detroit.

the iron having two valences, the corrosion takes place very rapidly. Practical stack builders are of the opinion that a stack must be made thick enough to allow one-fortieth of an inch of solid metal for each year that the stack is to be used. The actual corrosion is not quite as great as this, but it is a safe rule to say that when a stack has been up one year for each fortieth of an inch in thickness, the corrosion will be so bad that it is time to replace the stack. According to this rule an 18-gage stack, which is 0.05 in. thick, is only safe for two years, a 16-gage stack for about 2½ years, while a $\frac{3}{16}$-in. stack would be good for about 7½ years, a ¼-in. for 10 years and a ⅜-in. stack for 15 years. Observations of individual stacks would indicate that this rule is approximately correct.

It is a matter of common observation that the corrosion on the exterior of a stack, if kept painted, is an almost negligible quantity, and it is therefore unfortunately true that a stack may appear to be perfectly sound on the outside and yet be so badly corroded on the inside as to be dangerous.

Plates Are Lapped to Shed Rainwater

It is customary in building steel stacks to lap the plates so that the upper plate projects beyond the lower one and sheds the rainwater from the outside in the fashion of a shingle roof. Inasmuch as rainwater is by no means as corrosive as the acid condensate on the inside of the stack, this appears to be a grave error. A properly constructed stack should be so arranged that the upper plate would go inside of the lower plate, leaving a ledge for the rainwater on the outside, which can be protected by painting, but shedding the acid water on the inside of the stack.

In view of the theory outlined above, it is interesting to study the analysis of the scale found on the inside of a large stack which had been in service many years. This stack was some 140 ft. high and had originally been about ⅜-in. thick, but had corroded to approximately ⅛-in. and in places to less. The iron had been converted into thick plates of rust and samples of this material taken at a point about 25 ft. from the top of the stack, showed the following analysis: Iron 62.14 per cent; sulphur (as sulphate) 0.624 per cent; loss on ignition 11.65 per cent.

In order to make this analysis more comprehensible, the sulphur present as sulphate is calculated in terms of ferric sulphate. The remainder of the iron was then calculated in ferric oxide. The sulphur trixide formed from the sulphur was subtracted from the loss on ignition for the reason that the ferric sulphate is broken up upon igniting into ferric oxide and sulphur trioxide. The analysis would then be as follows: Ferric oxide 87.77; ferric sulphate 2.60; loss in ignition 10.15; Total, 100.52.

The loss in ignition was mostly water, although there was a minute trace of fine carbon. The total analysis is a trifle over 100 owing to the fact that some of the ferric oxide is converted into magnetic oxide when strongly ignited, and this means a slight loss of oxygen.

The significant facts of this analysis are that the scale was composed of about 97.4 per cent of hydrated ferric oxide, and about 2.6 per cent of ferric sulphate. If all of the sulphur originally present in the steel had been converted into sulphate, it would not amount to more than about one-twentieth of this amount, but as a matter of fact, during the corrosion the most of the sulphur is converted into hydrogen sulphide and escapes as such, while the sulphur observed was no doubt almost entirely due to the condensation of the sulphur dioxide on the cool walls of the upper part of the stack.

The results of the analysis amply confirm the theory set forth herein, and with these facts before him the plant engineer should be in a position to decide whether the cheap but short-lived steel stack is really worth building in place of the more expensive but more permanent masonry stack. *Bulletin of the Associated Engineering Societies of Detroit.*

Salient Factors in Combustion Control*

By E. G. Bailey†

A MODERN steam boiler plant involves three controls for the combustion process, fuel, forced draft and induced draft. To operate a plant satisfactorily, these three basic controls must be guided by certain definite results. The first of these is steam pressure. Steam pressure is an indication of balanced relation between the inflow and outflow of B.t.u. from the boiler proper.

When the steam pressure holds constant, it indicates an exact balance. When the steam pressure is dropping, it shows that the steam is carrying heat out of the boiler faster than the fuel is replenishing it, therefore the call for a higher rate of combustion. To supply this heat from coal or fuel in any form requires air, or in the case of a fuel bed if the coal is already on the grate, then the supply of air will be sufficient, but burning away of the coal calls for a replenishment of the fuel in order that the desired fuel-bed conditions be maintained. A drop in steam pressure therefore calls for simultaneous increase of both the fuel and air supply. In the case of stokers with fuel beds, the need for this exact synchronism of events is not so essential as it is in the case of pulverized fuel, gas or oil.

Relationship Between Fuel and Air

The second problem of control is the relationship between the fuel and air in order to maintain combustion efficiency. The relationship between fan speed or damper position and air supply is not at all accurate. Also, the relation between stoker speed, feeder speed, position of oil or gas valves does not hold a definite relation to the fuel supply. If these relationships did exist then every valve, every rheostat and every damper would be a meter and all we would need to do would be to record or note its position and the quantity of fluid or material passing through it would be known.

Experience has shown that the only feasible guide for combustion efficiency is to determine the percentage of excess air. The desired percentage of excess air for best combustion efficiency is that which will maintain the total losses due to excess air and unburned fuel at a minimum. Or, if the brickwork is the essential factor, as it often is, one should maintain the lowest percentage of excess air and yet not encounter too great an expense in maintaining the brickwork and furnace lining.

The steam-flow air-flow relation is a positive, instantaneous and correct indication of the percentage of excess air and is well adapted as a guide for either hand or automatic control. The rate of steam generated is in reality the reading of a calorimeter showing the rate at which B.t.u. are developed in a furnace. The flow of air as indicated by the differential pressure across the boiler with proper precautions, is a measure of the rate of air supplied to develop the B.t.u. Fortunately, the B.t.u. per pound of air used in combustion is substantially constant for all commercial fuels and the relation between steam flow and air flow is, in reality, a relation between the B.t.u. supplied to the furnace in a fuel and the air supplied to the furnace for burning the same with the desired percent age of excess air.

The Third Factor Is in the Furnace Draft Pressure

The third factor for controlling this combustion process is found in the furnace-draft pressure as being a balance between the induced draft and the forced draft. Balanced draft control is well known and has been used to great advantage for a number of years, but everyone realizes its limitations as it controls only one thing, the relation between outgoing gases and incoming air, and has completely ignored the all-essential factor of controlling the fuel supply to maintain steam pressure and also to vary the air supply in proportion to the fuel for best combustion efficiency.

The system of control that must be carried out for best results is the same whether it is done by hand or by automatic means. This involves simultaneous changing rate of fuel and air supply to meet the demand for steam, and then readjusting the induced-draft fan to obtain the desired percentage of excess air and also readjusting the forced-draft fan to maintain the proper

*Abstract from a paper, "Combustion Control," presented before the nineteenth annual convention of the Association of Iron and Steel Electrical Engineers, held in Pittsburgh, Sept. 15 to 20, 1924.

†President, Bailey Meter Company.

furnace draft. If the induced and forced draft have both been changed simultaneously with the fuel, they need only be slightly readjusted, using the excess air and the furnace draft as guides in obtaining the correct final adjustment. A good fireman with hand control does identically this very thing, and no system of automatic control will be successful unless it carries out the same procedure as a good man would do with good controllable equipment available for accomplishing any desired result called for as he observes the combustion and operating conditions.

Another point of particular importance in the control of boiler equipment is the feed water. It is obviously impossible to have the feed water controlled in proportion to the steam output without the net final result of water level in the boiler as the final controlling guide. In other words, the water level is the final guide as to whether the amount of water leaving the boiler in steam, leakage or blowoff has been replaced from the feed line. The control of the feed valves may have to be changed from time to time even though the rate of steaming has not changed, such change in feed valves being called for because of change in feed-line pressure or change in boiler pressure.

Combustion-Control System in Large Pulverized-Fuel Plant

In a large pulverized-coal fired boiler plant a system of combustion control is operated by a pilot-motor mechanism of special construction and handles several boilers from one master-control panel which can be either automatic or push-button regulated in case other than the standard pressure is desired or if for any reason the operator wishes to meet an emergency. From this central panel the control, either automatic or push-button, increases the fuel and air supply to each boiler simultaneously. The air supply is controlled by induced-draft fan motors, together with dampers for bringing the rating down to less than that corresponding to the lowest fan speed. The fuel is controlled by rheostats on the direct-current motors operating each individual feeder. The air to the hollow-wall ducts is controlled by spring-balanced dampers so as to maintain the desired distribution of air at the different levels.

At individual boiler panels each of the feeder motors can be started or stopped and it is necessary to stop some of these motors for the lower ratings, as all feeders at the lower speeds will supply enough coal for about 120 per cent of boiler rating.

It is also possible to stop and start the two induced-draft fans from this panel board, although they are normally stopped and started by the automatic control in conjunction with the damper position and the boiler rating required.

When bringing a boiler on the line or doing any unusual thing with it the operator has push-button control completely independent from the automatic. For instance, the central drum switch in No. 1 position enables the operator to supply more air by increasing the fan speed or opening the dampers according to their position, covering fans and dampers if they are both connected through from the individual drum switches to the central drum, or they can be controlled individually if desired. From the No. 2 position of the central drum switch the push buttons will then increase or decrease the supply of fuel. In No. 3 position the boiler is on base-load conditions and the drum switches will increase both the fuel and air for each individual boiler alone and the air will be automatically and continuously readjusted to suit the fuel supply. No. 4 position is the same except that it carries through to the central panel where the steam pressure or the push-button control at that point takes care of the capacity of this boiler, while the steam-flow air-flow readjustment accomplishes the desired results in maintaining the proper combustion efficiency.

Manufacturer Wrongly Blamed for Difficulties of Control

Many difficulties of automatic control have been laid at the door of the manufacturer of such equipment, while in reality it was the uncontrollable relationship between the factors that could not be properly obtained or maintained. To a certain extent the firemen on hand control have been greatly handicapped owing to the lack of proper relationship between the controller travel and the results obtained therefrom.

In one plant a 60-point rheostat was installed, yet only about ⅓ of the speed range of the pulverized-coal feeders could be used within the limit of the air supply, which was the maximum obtainable from the stacks themselves. In another case the lowest feeder speed gave over 200 per cent of boiler rating, and in similar conditions stokers are often found where the lowest speed obtainable would operate the boilers very nicely at 250 per cent rating, yet the fireman is called upon to operate the boilers on an average rating of 150 per cent, which can be accomplished in such cases only by stopping and starting the stokers.

The operator can obtain much better results in many cases if he is given good controllable motors and dampers over the desired range of operation, and furthermore, if such control is brought to the meter board or at a convenient place in the boiler front where he can observe operating conditions while changing the controls and maintain them as desired instead of having it scattered all over the boiler room, or not within reach at all.

Automatic control is not justified in all existing boiler plants, but there seems to be no good reason why all control necessary for the fireman to operate should not be brought to a common point with the proper metering equipment to indicate his operating conditions and thereby enable him to accomplish the best results without useless physical effort.

The average daily production of electricity by public-utility power plants in August was 152,700,000 kw.-hr., 2⅜ per cent greater than the revised figures for the daily output for the month of July.

Growth in Cast Irons

Growth, which is a permanent increase in volume of cast iron, some metals, and alloys, depends not only on the temperature and time, but also upon their compositions. White irons generally tend to shrink and gray irons to grow, but when the former variety contains appreciably more than 3 per cent carbon, there is a tendency to deposit temper carbon upon prolonged heating, and the metal will then grow.

An alloy which was found to remain at practically constant volume under repeated heating at 1,650 deg. F., turned out to be a white iron containing about 3 per cent of carbon and only small quantities of other constituents and in particular less than 0.2 or 0.3 per cent of silicon, according to Rugan and Carpenter. The latter stated that phosphorus tends to diminish growth, and that if 0.3 per cent is present, growth is lessened by about 3 per cent. The amount of sulphur usually present is not sufficient to have more than a minor influence.

Manganese not only retards the rate of growth but ordinarily diminishes the absolute amount.

Dissolved gases are negligible in effect when more than 3 per cent of silicon is present, but they may cause a growth of 1 to 2 per cent of irons containing 1.75 to 3 per cent of this element, and at least 10 per cent when silicon does not exceed one per cent.

As a result of his investigations Carpenter recommended the use of semi-steel containing about 0.6 per cent of silicon, 2.6 per cent of carbon, and 1.6 per cent of manganese for annealing ovens, rolls, fire bars, high-pressure steam valves and turbine casings where growth may be objectionable. Such metal showed no growth after 150 heatings to high temperatures, but on the contrary a slight contraction of about 0.13 per cent. The foregoing facts are cited in a paper by H. J. French and W. A. Tucker, read at the recent joint meeting of the Society of Mechanical Engineers and the American Society for Testing Materials.

When Is An Engine "Stationary"?

By A. L. H. Street

In the case of McDonough vs. Almy, 105 Northeastern Reporter, 1012, it was decided that where an engine was so bolted to a concrete foundation as to be free from vibration and immovable excepting as released from the foundation, it was properly classed as a "stationary engine" within the meaning of a regulatory ordinance, although it was not intended to be used at the particular location for more than two or three years.

A plant was set up for the removal of a ledge of rock under contract. Question arose whether or not the power equipment was governed by a local ordinance providing that "No . . . stationary steam boiler from which power is to be taken or any other fuel than coal or coke is to be used to create steam and no stationary steam

engine shall be hereafter erected or put up or used in this city without a license obtained from the board of aldermen; provided however that no such license shall be required for such an engine unless the same is to be erected within five hundred feet of a dwelling house or a public building."

"The plaintiff contends that the engine erected by him was not stationary, but portable, and that therefore the ordinance did not apply," said the court. "There is no controversy between the parties as to the manner in which the engine was installed or the length of time it would remain upon the defendant's land in the performance of the work. The evidence shows that it was set upon a concrete foundation and bolted and braced to the concrete in such a manner as to be stationary and immovable, and free from vibration. There was also evidence to show that it would be used in the same location for a period of at least two or three years. Whatever may have been the character of the engine when it was brought to the plaintiff's land, we have no doubt that when it was set upon the concrete foundation and permanently [?] attached thereto for the purpose of being used two or three years, it became a 'stationary steam engine' within the meaning of the ordinance. The word 'stationary' is defined as 'fixed in a certain station,' 'a steam engine permanently placed'; while 'portable' accurately describes an object 'capable of being borne or carried; easily transported. . . .' Accordingly the ruling that the engine was a 'stationary steam engine,' as that term was used in the ordinance, was correct."

With all respect to the learned court, it seems to me that its reasoning involves a contradiction of terms, howsoever proper it may be, in the light of common understanding, to treat the engine in question as being stationary. The contradiction consists in speaking of an engine being installed in a given location there to remain *permanently* for two or three years.

States and Cities Adopting A.S.M.E., 1924 Edition, Boiler Code

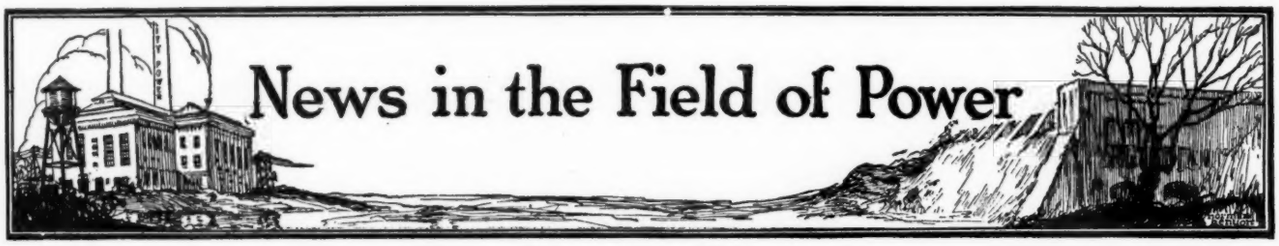
The American Uniform Boiler Law Society, 253 Broadway, New York, addressed the following questions to the Boiler Inspection Departments of the States and Cities that adopted the 1918 Edition of the A.S.M.E. Boiler Code:

1.—"Will boilers and appurtenances built in accordance with the 1924 Revised Edition of the Boiler Code, be accepted by your department?"

2.—"Have you allowed or do you contemplate allowing a reasonable length of time to elapse before adhering strictly to the 1924 Revised Edition, in order that manufacturers who have stock boilers in warehouses built in accordance with the 1918 Edition of the Code may have time to dispose of such boilers?"

States	Have Adopted or Will Accept 1924 Edition	Will Adopt 1924 Edition Later	Will Allow Time for Disposal of Boilers Built Under 1918 Edition	Remarks
Rhode Island	Will accept	Will adopt	Yes	Until further notice
New York	Will accept	Will adopt	Yes	Reasonable length of time
New Jersey	Will accept	Will adopt	Yes	Boilers now being built must be in accordance with 1924 Code
Pennsylvania	Will accept	Will adopt	Yes, if manufacturers' data sheets have been filed in their office	Time allowance will be determined by the Industrial Board
Delaware	Will accept	Will adopt	Yes	New rules will not go into effect for at least six months
Maryland	Have adopted			Approved and adopted as standard of construction for power boilers
Michigan	"Until further notice, boilers constructed according to either the 1918 or the 1924 edition of the A.S.M.E. Code, will be accepted by the Michigan State Board of Boiler Rules."			
Ohio	Have adopted	In effect Jan. 1, 1925	Yes	Will accept stock boilers built to 1918 Code at any time in the future
Indiana	Will accept	Will adopt	Jan. 1, 1925	Manufacturers' data sheet must state whether boiler is built to 1918 or 1924 Code
Wisconsin	Will accept		Yes	Boilers built to 1918 or 1924 Code will meet Wisconsin requirements
Minnesota	Will accept		Yes	Reasonable length of time
Missouri	Have adopted			
Washington	Will accept	Will adopt	Reasonable time	1918 Code boilers and appurtenances accepted when built in accordance with State Safety Standards adopted Jan. 1, 1924
California	Will accept	Will adopt	Yes	
Oregon	Will accept	Will adopt	Yes	This applies to stock boilers. New boilers should be built under 1924 Code
***Utah**				
Oklahoma	Will accept	Will adopt	Yes	
Arkansas	Will accept	Will adopt	Yes	
Panama Canal Zone	The War Department has referred the matter to the Engineers of the Canal Zone, and states that "they have previously followed the A.S.M.E. Boiler Code and undoubtedly will continue to do so."			
District of Columbia	"The Commissioners of the District have approved the A.S.M.E. Boiler Constructive Code — effective immediately."			
Boiler Inspection Department-Hawaiian Sugar Planters' Association	"Specifications call for all boilers to be built in accordance with the latest edition of the Boiler Code of the A.S.M.E." Boilers built according to the 1924 Code accepted. Stock boilers built according to 1918 edition will be accepted, providing contract is signed prior to Jan. 1, 1925 —after that date, 1924 Code should be followed.			
Detroit, Mich.	Will accept		Yes	Reasonable length of time
Erie, Pa.	Will accept	Will adopt	Yes	Applies to Power, Locomotive and Heating Sections of 1924 Code
***Kansas City, Mo.**				
St. Louis, Mo.		Will adopt		Detailed information later
St. Joseph, Mo.	Will accept	Will adopt		1918 Code stock boilers will be accepted to Jan. 1925
Philadelphia, Pa.	Will not accept	Will adopt	Yes	1918 Code in effect until 1924 Code is adopted
Los Angeles, Calif.	Will accept	Will adopt	Period of one year beginning Aug., 1924, ending Aug., 1925, if built prior to adoption of 1924 Code	Thereafter will adhere strictly to 1924 Code
Tampa, Fla.	Will accept	Will adopt		1924 Revised Code will be effective Jan. 1, 1925
Chicago, Ill.	Will accept		No particular date	1918 Code stock boilers accepted at the manufacturers' request
Nashville, Tenn.	Will accept	Will adopt		No action taken as yet as to length of time for the 1918 Code to be eliminated
Memphis, Tenn.	Will accept			Will accept both Codes
Scranton, Pa.	"All boilers that will be acceptable to the Department of Labor and Industry, Harrisburg, Pa., will be accepted by this Department for operation in the City of Scranton."			
Seattle, Wash.	Will accept	Will adopt	Undecided as to time	Under City Charter automatically accept the Code as revised from time to time
Parkersburg, W. Va.	"All boilers and appurtenances built in accordance with the 1924 edition of the Code will be accepted. All boilers constructed before July 1, 1924, in accordance with the 1918 edition will be accepted. All boilers constructed after July 1, 1924, in accordance with 1918 Code, will be accepted until July 1, 1925."			
Omaha, Neb.	Will accept	Will adopt	Yes	Reasonable length of time for disposal of 1918 Code boilers

* No reply as yet. Please communicate with us later for additional information.
Corrected to October 1, 1924.



Henry Ford Withdraws Bid on Muscle Shoals

His Business Has Passed by Muscle Shoals Owing to the Long Political Delay, Says Ford

THAT Henry Ford is withdrawing his bid for Muscle Shoals, but will consider an offer from the government, was announced in a current issue of *Collier's Weekly*.

The reason for the withdrawal is given in the interview in part as follows:

"Muscle Shoals," said Mr. Ford, "That is not a live issue with us any longer. More than two years ago we made the best bid we knew how to make. No definite action has been taken on it. A simple affair of business which should have been decided by anybody within a week has become a complicated political affair. We are not in politics and we are in business. We do not intend to be drawn into politics." . . .

"Yes, we have made our bid; now let them make us a bid, and they will not have to wait three years for an answer. We can tell them in five minutes."

"A great business enterprise can never stand still. We have been doing a great many things since first we were asked to bid on Muscle Shoals. We needed coal to make coke out of to use in the blast furnaces at our River Rouge plant and so, from time to time, we have bought coal lands which we expect to reach by the Detroit, Toledo & Ironton Railroad. We have finally completed the buying of a considerable number of other coal properties so that now we have about 160,000 acres of coal lands in Kentucky, about 200 miles from Muscle Shoals and about seventy-five miles from the terminus of our railway.

"We find from our experience at the River Rouge plant that we can generate electrical power in these coal lands to any extent that we may need and at a cheaper rate than we could under our bid at Muscle Shoals. And also we can generate in our own way entirely outside of all political influences or political meddling. That is why we have lost interest in Muscle Shoals."

"But why, if all this power was already at hand in the coal fields, did you ever bother with Muscle Shoals at all?"

"We did not bother with Muscle Shoals," corrected Mr. Ford. "We were asked by the War Department to salvage a national asset. The thing interested me, and our bid represented what we believed we could do. Besides, when we were first approached we did not have the coal and engines and turbines which we now have. That is, when we bid for Muscle Shoals we could have used it. Now we can achieve the same results in another way."

Ford Takes Washington by Surprise

Political Washington, taken by surprise by the withdrawal of the Ford bid, shows little crystallization of opinion with regard to which one of the alternate propositions for the property should be best as these alternate propositions have been entirely incidental to the analysis of the Ford offer. The President still is of the opinion, it was stated at the White House, that a committee to be composed of subcommittees of the Senate Committee on Agriculture and of the House Military Affairs should take over the matter. It was emphasized at the White House that the disposition of Muscle Shoals is a congressional and not an executive affair. Commerce Secretary Hoover, realizing the difficulty of reaching a business-like determination of an engineering problem by a political commission, suggests that an "objectively minded and skilled" committee also be employed.

The plant at Muscle Shoals will be ready to deliver power on June 15. If Congress should refuse to delegate the responsibility of handling the problem, either to the Secretary of War or to the Federal Power Commission, delay will be inevitable in its utilization.

Plans Being Made for Power Plant at Monterey, Mexico

Construction of a large hydro-electric power plant in the mountains near Monterey, Mexico, is proposed by Barton Monroe, of London, and Associates, according to M. F. Lewis, consulting engineer, who is investigating the situation. The project will involve the building of one or more large dams for the storage of water, and the construction of a generating plant and extensive power transmission system. More than 200,000 hp. will be furnished to industrial plants in Monterey, including the $10,000,000 iron and steel plant, the smelters, glassworks and brewery. Mining camps in that district will also be supplied with power, and electrification of the National Highways of Mexico between Monterey and Saltillo is among the possibilities when the plant is finished, according to recent press reports.

Shipping Board Opens Diesel Bids

The Shipping Board opened bids, Oct. 14, on Diesel engines to be installed on twelve 8,800- and 9,600-ton ships. Twelve principal builders offered units ranging in capacities from 2,150 to 3,432 brake horsepower. While up to the present time only one American builder has actually constructed a double-acting engine, the majority of the offers were for this type of machine. Several manufacturers have taken out European licenses for double-acting units and have done considerable development work in the drafting room and pattern shop. It is expected that the Shipping Board will arrive at an early decision, and indications are that the contracts will be distributed to several of the bidders.

The outstanding point of interest is the wide discrepancy in the bids. Offers as low as $60 per horsepower were received, while the top bid was at $125 for single-acting two-stroke-cycle engines. On a basis of horsepower rating the prices are much higher than the Isthmus of Panama bids but on engine dimensions the bids are practically on a parity.

BIDS ON DIESEL ENGINES RECEIVED BY THE SHIPPING BOARD

Manufacturers	Type	Horse-power	Cost One Engine	Cost per Hp.	Cost 2 Engines	Cost per Hp.	Cost 3 Engines	Cost per Hp.	Cost per Hp. Additional Units
Bethlehem	Two-stroke cycle single-acting	2,225	$278,500	$125	$529,000	$119	$735,000	$110	$105
Busch-Sulzer	Two-stroke cycle single-acting	3,000	339,700	113	605,000	101	856,000	95	92
Cramp	Four-stroke cycle single-acting	2,500	320,000	128	614,000	123	896,000	119	110
Falk	Four-stroke cycle single-acting geared	2,400	169,000	70	322,000	67	477,000	66	63
Hoover-Owen-Rentschler	Two-stroke cycle double-acting	3,050	.....	...	534,000	88	.....	...	...
McIntosh & Seymour	Four-stroke cycle single-acting	2,600	290,900	118	561,925	108	837,450	107	99
New London	Two-stroke cycle double-acting	3,000	210,000	70	410,000	68	609,000	68	66
New York Shipbuilding	Four-stroke cycle double-acting	3,432	205,000	60	410,000	60	.....	...	...
Nordberg	Two-stroke cycle double-acting	3,000	350,000	117	580,000	97	810,000	90	82
Pacific Diesel	Four-stroke cycle single-acting	2,150	192,500	90	367,000	85	529,500	82	82
Sun	Two-stroke cycle single-acting	2,500	195,000	78	390,000	78	585,000	78	78
Worthington	Two-stroke cycle double-acting	2,900	243,224	84	440,214	76	625,661	72	60

Annual Meeting Plans of the A.S.M.E. Take Shape

The Committee on Meetings and Programs is arranging the plans for the coming Annual Meeting of the A.S.M.E. which is to be held Dec. 1-4 in New York City with a view of giving an increased opportunity for new members to get acquainted with the older members. To that end open house will be held on Monday evening, Dec. 1, the Presidential Reception following the Presidential Address on Tuesday evening, the Ladies Tea and Reception on Wednesday afternoon and the Annual Dinner on Wednesday evening. Elaborate arrangements are being made to entertain the ladies who accompany their husbands to the meeting.

At the dinner, which is to be the climax of the meeting, there will be one speaker of international reputation. The remainder of the evening will be devoted to a brief greeting to the men who have joined the Society during the preceding year and who have not had the opportunity of enjoying an annual meeting of the Society. They will be introduced to the Society and its officers, and be made acquainted with its ideals and activities. The technical papers program will be announced later.

Detroit Edison Building New Plant at French Landing

Construction was started on the Detroit Edison's sixth and largest hydro-electric plant on the Huron River on July 15. The dam will consist of an earth embankment about 750 ft. long, a spillway 180 ft. long, consisting of concrete arches, two sector gates each 33 ft. wide and the power house. In the power house there will be installed two Francis-type turbines and generators built by the Allis-Chalmers Co., having capacities of 2,100 kva. and 1,000 kva. at a head of 33 ft. The plant will not only be a generating station, but also a distributing station for small towns in this section.

The generating plant will be remote controlled by the system operator at Superior, ten miles up the river. The system operator will be able to tell at all times what the elevation of the water is above the plant, which machine is on the line, and the gate opening at which it is operating. The method of controlling one of the units will be as follows: The system operator will close the switch at Superior on the unit he wants started up; this will energize the solenoid on the governor, and the latter will open the turbine gates, permitting flow to the wheels. When the generator is in synchronism with the rest of the system, a special synchronizing device will cause the oil circuit breaker on the generator to close, putting the generator on the line. The governor will open the gates of the turbine to whatever gate opening it is set for. To shut the system down the system operator will open the control switch at Superior and the unit will be taken off the line and shut down. In case of any trouble within the generator or in the bearings, the unit will immediately be taken off the line and a signal sent in to Superior. There will be one gate on each side of the power house, and these will be used in time of high water to let down the surplus water which is not being used through the wheels.

General Tripp Talks on Politics and Power

The superpower idea, as discussed by Guy E. Tripp before the New York Section of the A. I. E. E. on Oct. 15, must live down an unfortunate name—one which signifies domination. The principle does not refer to mere interconnecting lines between systems, but rather to major arteries for transmission of power, so that insufficient generation in one district may be counteracted by more favorable conditions in another. Hydro-electric power may thus be utilized to better advantage and less reserve steam equipment required.

Although fear of domination may influence public opinion strongly toward government ownership, private ownership with public control has proved highly beneficial in this century, where only 5½ per cent of public-service generation and 2 per cent of electric railways are publicly owned. In Great Britain, however, two-thirds of the installed public-service generators and of the electric railways are publicly owned. The Lloyd George Committee, however, has recommended power systems for that country patterned after the United States, but with private ownership. Efficiency was stressed as being characteristic of private enterprise to a markedly greater extent than with public administration.

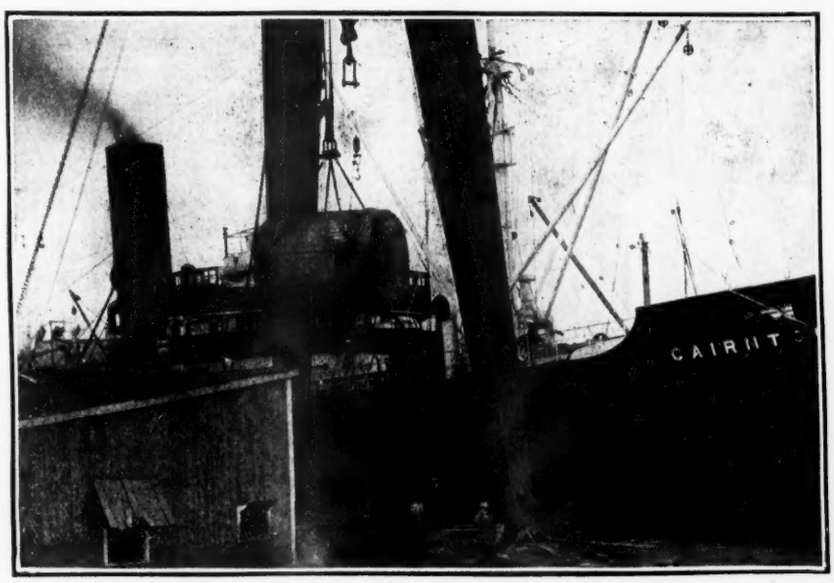
Turbine Reliability More Important than Efficiency, Says Hodgkinson

After Mr. Tripp, Francis Hodgkinson addressed the meeting, saying that low steam velocities with higher pressures appeared to be universally favored. Turbine efficiency did not represent over-all plant economy and reliability was the most important factor in obtaining the latter. For large turbines the cross-compound principle made it possible to improve both efficiency and reliability. Speeds of the high- and low-pressure elements could thus be better suited to design requirements; temperature and pressure variations are made less for an individual cylinder, and the close proximity of thrust bearings to blades makes closer radial clearances sometimes possible in the lower pressure ranges. Pipe thrusts are more easily taken care of where reheating is employed, as connections are at each end of each cylinder when cross-compound, rather than being at each end as well as in the middle for a single-cylinder unit.

American Superpower Corp. Buys Stocks in Big Companies

Well-authenticated reports from Philadelphia are to the effect that the American Superpower Corp., incorporated under the laws of Delaware in November, 1923, to acquire interests in various power and light companies in the United States and to co-operate with the management of such companies in furthering the best interests of the electrical industry, now holds stock in the Public Service Corp. of New Jersey, the Brooklyn Edison Co., the Commonwealth Power Corp., the United Light & Power Co., the Tennessee Electric Power Co., the Appalachian Power Co., the Republic Railway & Light Co. and other companies.

Among those interested in the American Superpower Corp. as directors are Randal Morgan, vice-president United Gas Improvement Co.; T. N. McCarter, president, and P. S. Young, vice-president Public Service Corp. of New Jersey; S. Z. Mitchell, president Electric Bond & Share Co., New York; Landon Thorne, president, and Alfred L. Loomis, vice-president Bonbright & Co.; B. C. Cobb, president Consumers Power Co.; Frank Hulswit, president United Light & Power Co.; George Hardy, president Commonwealth Power Corp.; Ray P. Stevens, president Re-



One of the alternators, weighing 171,000 lb., for the 50,000-kw. British Parsons turbine for the Crawford Avenue station, Chicago, being unloaded

public Railway & Light Co.; W. M. Flook, president Tennessee Electric Power Co.; H. L. Stimson, former Secretary of War; W. S. Murray, consulting engineer, New York, and George Roberts, counsel to the company.

The primary source of earnings of the American Superpower Corp. will be from holdings of stock in the companies in which investment has been made.

Engineer's Bookshop Started in New York City

An Engineer's Bookshop, which is open in the evenings, and which is not only for the sale of books, ancient and modern, but a place where information service and varied aid to the engineers, manufacturers, students and research workers will be given has just been opened at 126 East 41st St., New York City, by Elfrida Harder.

It is the aim of Miss Harder to make the shop headquarters for busy technical people; a place where they may obtain information easily, not only of an engineering nature but of an economic nature as well. Ancient reports will be dug up and pages photostatted, translations will be made, living conditions in foreign countries, manners and customs, languages, maps, in fact, all the help that is needed by the engineering profession, will be given by the information service.

Bituminous Coal for August—Production, Export, Stocks

According to the Bureau of Foreign and Domestic Commerce, there was 34,765,000 net tons of bituminous coal produced during August. This department is also authority for the statement that 1,392,862 tons were exported during the same month. The Bureau of Census gives the situation in regard to coal stocks.

"The Government's inventory of coal stocks taken recently revealed the following facts: Commercial stocks of soft coal on Sept. 1, 1924, totaled 47,000,000 net tons, a decrease of 4,000,000 tons from stocks on June 1, and 15,000,000 tons from the record of Jan. 1, 1924; the course of stocks has been constantly downward since the early weeks of the year; stocks on Sept. 1, 1924, were 9,000,000 less than on the same date a year ago, and were more than double those on Sept. 1, 1922, at the close of the miners' five months' strike; compared with Aug. 1, 1921, there was an increase of 6,000,000 tons."

Power Possibilities of Fundy Being Studied

Surveys are being made of the practicability of harnessing the tides in the Bay of Fundy and adjacent waters without interference to navigation. Sufficient power can be generated at the Lubec Narrows to turn the wheels of every industry in New England, it is estimated. The project, if attempted, it is stated, will be a larger engineering undertaking than the construction of the Panama Canal, and will call for massive concrete tidal dams, costing many millions to erect, according to *Commerce Reports.*

St. Maurice Power Completes La Gabelle Project

The St. Maurice Power Co., Ltd., has completed its big hydro-electric development at La Gabelle, on the St. Maurice River, which is about 14 miles above Three Rivers and 10 miles below Shawinigan Falls.

On Sept. 14 the fourth and final unit of 30,000 hp. capacity began operating, five and a half months ahead of the limit provided in the first schedule for construction.

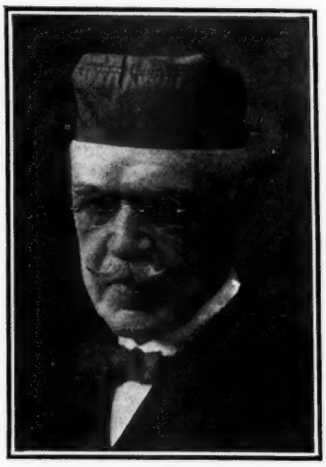
At the present time the four installed units are delivering approximately 100,000 24-hour hp. The rated capacity of the plant is 120,000 hp. The delivery of power will be steadily increased from now on, leaving the usual peak load balance available.

The actual erection of the machinery for the first unit was begun early in January, 1924. This unit was completed on March 24, and power was ready for delivery on April 13. Approximately one month later, May 16, the second unit was brought in. On July 24 the third unit started operation, followed by the fourth and final unit on Sept. 14. The eastern end of the power house includes space for a fifth unit should such be found necessary or desirable.

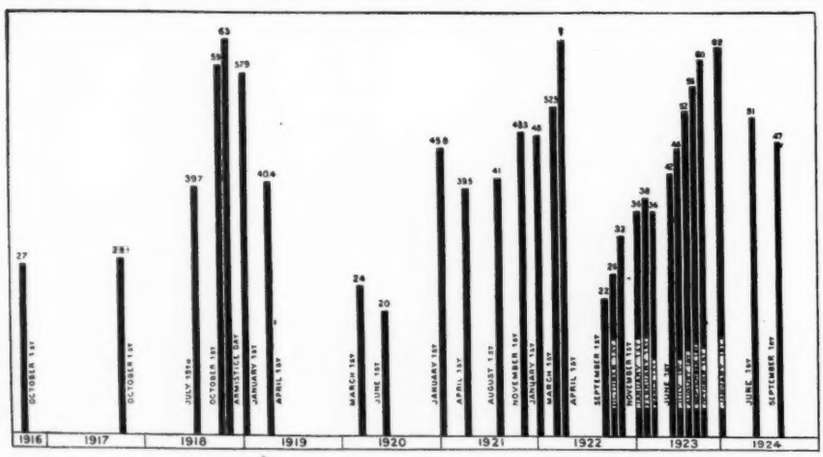
The units installed were manufactured and supplied by two Canadian firms, the Dominion Engineering Works, Ltd., building the turbines and the major electrical equipment was constructed by the Canadian Westinghouse, Ltd.

Famous Maker of Locks Dies on Oct. 15

Henry Robinson Towne, former president of the A.S.M.E. and for many years president of Yale & Towne Mfg. Co., makers of locks, Stamford, Conn., died on Wednesday evening, Oct. 15 at his residence in New York City. He was born in Philadelphia in 1844 and studied at the University of Pennsylvania during 1861-62, receiving Hon. A.M. there in 1887. He began his active career as an engineer by entering the drafting room of the Port Richmond Iron Works. In 1864-66 he was in charge of erecting engines in the monitors "Monadnock" and "Agamenticus" and similar work until the war closed. After the war he became a special student of Robert Briggs, carrying on numerous experiments on leather belting, accepted as standard for about twenty years. He also took a special course in physics at the Sorbonne in Paris, about this time. In the summer of 1868 he became associated with Linus Yale in the manufacture of locks, where for almost thirty years every improvement in locks or lock making came through his keen ability as mechanic and business man, and after Mr. Yale's death he became president of the company. Mr. Towne was a life member of the A.S.M.E., vice-president 1884-86 and president 1888-89. He wrote many technical papers, chief of which were "Towne on Cranes, 1883" and "Locks and Builders' Hardware."



Henry Robinson Towne



Total commercial stocks of bituminous coal, Oct. 1, 1916, to Sept. 1, 1924

Figures represent million net tons and include coal in the hands of railroads, industrial consumers, public utilities and retail dealers. Coal for steamship fuel, on Lake docks, in transit, and in the bins of householders is not included. Figures for 1923 and 1924 are subject to revision.—Bureau of Census and Geological Survey.

Plants in New Zealand at the present time, it is reported, aggregate 26,000 hp., while those in the course of erection will total 189,000 horsepower.

Personal Mention

George Beal, division engineer, Water Resources Service, Pennsylvania Department of Forests and Waters, was the author of the very good paper on "Development of Water Power in Pennsylvania," published on page 628 of the Oct. 14 issue of *Power*. This paper was given at the Fifth Annual Conference of State Foresters at Mont Alto, Pa., Aug. 14-15. The author, date and place of the conference were inadvertently omitted from our abstract.

Society Affairs

The Metropolitan Section of the A.S.M.E. will hold a smoker and get-acquainted party at the Hotel Astor, New York City, on Nov. 6.

The Nebraska Section of the A.S.M.E. will hold a joint meeting of Student A.S.M.E. of the University of Nebraska, with the Manufacturers Association, on Nov. 14. Dean Walker of the University of Kansas will speak on the "New Era in Industry."

The Hartford Section of the A.S.M.E will hear Dr. S. W. Stratton, president of the M.I.T., speak on "The Training of Young Men as Engineers in the Industry." The meeting will be held in the lecture room of the Hartford Electric Light Co., on Nov. 10.

The Engineers' Society of Milwaukee, Wis., has scheduled a meeting for Nov. 19, which will be devoted to Diesel engines. The principal speaker will be a prominent engineer from the Nordberg Manufacturing Co., and there will be other speakers who are connected with concerns manufacturing Diesel engines.

The Baltimore Section of the A.S.M.E. will have as the attraction for its Nov. 1 meeting, which will be held in conjunction with the A.I.E.E., a trip of inspection to the United States Naval Engineering Experiment Station and of the grounds and buildings of the Naval Academy. There will be a morning technical session at the Experimental Station and an evening session at Carvel Hall.

Business Notes

The Sessions Engineering Co., of Chicago, Ill., has opened a Western district office at Portland, Ore., in the Northwestern Bank Bldg. H. F. Winte is in charge.

Betson Plastic Fire Brick Co., Inc., Rome, N. Y., has recently started a new factory at 82 Dock St., St. Louis. This was decided upon when an addition to the Rome factory became imperative. Schroeder & Curry, combustion and sales engineers, are the active representatives and distributing executives in charge of the new plant, with offices at 211 Buder Bldg., St. Louis, Mo.

The Conveyors Corp. of America, manufacturer of coal- and ash-handling equipment, 326 West Madison St., Chicago, Ill., announces the appointment of the W. P. McKenzie Co., 1234 Callowhill St., Philadelphia, Pa., as its sales representative in southeastern Pennsylvania and southern New Jersey.

Coming Conventions

American Association for the Advancement of Science. Burton E. Livingston, Smithsonian Institution Washington, D. C. Meeting at Washington Dec. 29-Jan. 3, 1925.

American Ceramic Society. R. C. Purdy, Lord Hall, Ohio State University, Columbus, Ohio. Convention at Columbus, Ohio, Feb. 16-21.

American Institute of Chemical Engineers. Dr. John C. Olsen, Polytechnic Institute, Brooklyn, N. Y. Annual meeting at Hotel Schenley, Pittsburgh, Pa., Dec. 3-6.

American Society of Civil Engineers. 29 West 39th St., New York City. Fall meeting at Hotel Fuller, Detroit, Oct. 23-25.

American Society of Mechanical Engineers. Calvin W. Rice, 29 West 39th St., New York City. Annual meeting at New York City, Dec. 1-4.

American Society of Refrigerating Engineers. W. H. Ross, 35 Warren St., New York City. Annual meeting at New York City, Dec. 1-3.

American Welding Society. Miss M. M. Kelly, 29 West 39th St., New York City. Convention in Cleveland, Hotel Winton, Oct. 30-31.

Eastern Ice Manufacturers Association. W. H. Ross, 35 Warren St., New York City. Eighteenth annual meeting at Hotel Chelsea, Atlantic City, N. J., Nov. 12-14.

Electrical Exposition. Lincoln Bancroft, 124 West 42nd St., New York City. Exposition will be held at the Grand Central Palace, New York City, Oct. 15-25.

Engineering Institute of Canada. Fraser S. Keith, 176 Mansfield St., Montreal, Que. Annual meeting at Montreal, Que., Jan. 27-29.

Exposition of Inventions. E. W. Bartlett, 47 West 34th St., New York City. Exposition at Engineering Societies Building, 29 West 39th St., New York City, Dec. 8-13.

Illuminating Engineering Society. Norman D. MacDonald, 29 West 39th St., New York City. Convention at Briarcliff Lodge, Briarcliff Manor, N. Y., Oct. 27-31.

Iowa Engineering Society. J. S. Dodds, Box 202, Ames, Iowa. Convention at Des Moines, Iowa, Jan. 27-30, 1925.

National Association of Practical Refrigerating Engineers. E. H. Fox, 5707 West Lake St., Chicago, Ill. Convention at New Orleans, La., Nov. 11-14. Exhibits at the Isaac Delgado High School.

National Exposition of Power and Mechanical Engineering. C. F. Roth, Grand Central Palace, New York City. Annual exposition at New York City, Grand Central Palace, Dec. 1-6.

Society of Automotive Engineers. C. F. Clarkson, 29 West 39th St., New York City. Annual meeting at Detroit, Mich., Jan. 20-23.

Society of Naval Architects and Marine Engineers. Daniel H. Cox, 29 West 39th St., New York City. Annual meeting at 29 West 39th St., New York City, Nov. 13-14.

Stoker Manufacturer Association. W. V. McAllister, Detroit, Mich. Fall meeting at Seaview Golf Club, Absecon (Atlantic City), Oct. 28-30.

Western Association of Electrical Inspectors. G. M. Miller, 1304 South 7th St., Louisville, Ky. Annual convention at the Brown Hotel, Louisville, Ky., Jan. 27-28.

Trade Catalogs

Pumps, Sewage—De Laval Steam Turbine Co., Trenton, N. J. Bulletin E-1070 shows the action, installation and design of these open impeller pumps. Clear and well-chosen illustrations enhance the value of the pamphlet for reference.

Expansion Joint—Henry Pratt Co., 2222 South Halsted St., Chicago. Bulletin J-3, recently issued, gives the salient features and applications of the new Phillips expansion joint designed as a flexible connection between a steam-turbine exhaust flange and the condenser inlet.

Castings, Manganese Steel—American Manganese Steel Co., Chicago Heights, Ill. This company issues a loose-leaf catalog on "AMSCO" products. Especially interesting to power-plant men are the pages devoted to manganese steel, gears and pinions, chains, screens, elevated buckets and crushers for fuel. Considerable engineering data are contained in these pages, which are well illustrated.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	Oct. 6, 1924	Oct. 13, 1924
Pool 1	New York	$3.00	$3.00
Smokeless	Columbus	2.35	2.35
Clearfield	Boston	2.35	2.35
Somerset	Boston	2.40	2.40
Kanawha	Columbus	1.55	1.55
Hocking	Columbus	1.75	1.75
Pittsburgh No. 8	Cleveland	1.90	1.90
Franklin, Ill.	Chicago	2.50	2.50
Central, Ill.	Chicago	2.25	2.25
Ind. 4th Vein	Chicago	2.50	2.50
West Ky.	Louisville	1.90	1.90
S. E. Ky.	Louisville	1.90	1.75
Big Seam	Birmingham	1.75	1.75

FUEL OIL

New York—Oct. 17, light oil, tank-car lots; 28@34 deg. Baumé, 4¾c. per gal.; 36@40 deg. 5c. per gal., f.o.b. Bayonne, N. J.

St. Louis—Oct. 7, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.70 per bbl.; 26@28 deg., $1.75 per bbl.; 28@30 deg., $1.80 per bbl.; 30@32 deg., $1.85 per bbl.; 32@36 deg., gas oil, 4.8c. per gal.; 38@40 deg., 5¾c. per gal.

Pittsburgh—Oct. 16, f.o.b. local refinery; 30@34 deg., fuel oil, 5c. per gal.; 36@40 deg., fuel oil, 5¼c. per gal.

Dallas—Oct. 16, f.o.b. local refinery, 26@30 deg., $1.20 per bbl.

Philadelphia—Oct. 16, 28@30 deg., $2.10@$2.15 per bbl.; 18@22 deg., $1.87½@$1.93¾; 13@16 deg., $1.75@$1.81½ per bbl.

Boston—Oct. 14, tank-car lots, f.o.b.; heavy oil, 12@14 deg. Baumé, 4.2c. per gal.; light oil, 28@32 deg. Baumé, 5½c. per gal.

Cincinnati—Oct. 14, tank-car lots f.o.b. local refinery, 24@26 deg. Baumé, 5c. per gal.; 26@30 deg., 5¼c. per gal;. 30@32 deg., 5½c. per gal.

Chicago—Sept. 29, 20@22 deg., 5½c. per gal.; 24@26 deg., 6c. per gal.; 28@30 deg., 6c. per gal.

New Plant Construction

Calif., Firebaugh—The City had plans prepared for a sewage disposal plant, including pump pit, Imhoff tank, centrifugal pumps with electric motors, etc. F. A. Gamboni, 515 Brix Bldg., Fresno, is engineer.

Calif., Los Angeles—Lodge 99, B. P. O. Elks, Olive St., awarded the contract for the construction of a 12 story lodge building at 6th and Parkview, including complete refrigerating and steam heating system, estimated cost $1,500,000. Curlett & Beelman, 408 Union Bank Bldg., are architects.

Calif., Los Angeles—Public Service Commission, 207 South Broadway, J. P. Vroman, Secy., will receive bids until Oct. 24 for Diesel engine generating sets. Spec. 731.

Calif., Monterey—The City, A. J. Mason, City Clk., plans to purchase one pneumatic ejector of 100 gal. capacity complete with reducing valve, operating valve, floats, check valves, etc., also complete compressor plant consisting of single acting compressor of 23 cu.ft. per min., displacement, direct geared to a 5 hp., 220 v., 3 phase, 60 cycle squirrel cage motor, complete with automatic starting unloader, automatic start and stop mechanism controlled by pressure switch and a 2 ft. x 5 ft. receiver with pressure gage, safety valve drain valve and inlet and outlet connection.

Calif., Oakland — East Bay Municipal Utility Dist., plans to vote a $39,000,000 bond issue to develop Mokelumne River project for mountain water supply system, involving the construction of Lancha Plana reservoir, 325 ft. high to impound 200,000 ac.ft. and Arroyo Seco reservoir to impound 1,000,000 ac.ft. Aqueduct 87 mi. steel pipe conduit and about 8 mi. short tunnels through Contra Costa Hills. A. F. Davis is chief engineer, G. W. Goethals and W. Mulholland consulting engineers.

Calif., Redwood City—San Mateo County, E. H. Werder, Purch. Agt., plans to purchase pipe, valves, triplex pump, wooden tank approximately 50,000 gals. and other equipment for waterworks.

Calif., San Francisco—California State Automobile Ass'n, 1628 Van Ness Ave., awarded the contract for the construction of 4 story office building on Hayes and Van Ness Aves., to P. J. Walker Co., Sharon Bldg., approximately $500,000.

Calif., San Francisco—Clift Hotel, Geary and Taylor Sts., awarded the contract for the construction of a 13 story hotel annex, estimated cost $1,500,000.

Calif., Tracy—Banta-Carbona Irrigation Dist., awarded contract for pumps and motors to Byron & Jackson Pump Mfg. Co., Sharon Bldg., San Francisco, about $80,000. Miscellaneous equipment including valves and installing plants to L. F. Youdall, Matson Bldg., San Francisco, $47,782.

Conn., Meriden—The Millbrook Dairy Co., 41 Broad St., Middletown, awarded the contract for the construction of a 2 story dairy building, on Liberty St., including ice cream machinery, sterilizers, etc.

Ia., Tabor—The City awarded contracts for dam, spillway and filter for waterworks, bids will be taken later on pumps.

La., Sterlington — Arkansas Light & Power Co., Pine Bluff, Ark., is having preliminary plans prepared for the construction of an electric light and power plant, including equipment. Ford, Bacon & Davis, 115 Broadway, New York, are engineers.

Mass., Somerville—Acme Wet Wash Co., 40 Hawthorne St., is in the market for a steam engine, 22-30 hp. automatic governed.

Mich., Detroit—American Bond & Mortgage Co., 1247 Griswold St., awarded the contract for the construction of an 18 story apartment house on East Jefferson Ave., estimated cost $2,000,000.

Minn., Faribault — The City, S. M. Andrew, City Recorder, has retained A. L. Mullergren, Consulting Engineer, Gates Bldg., Kansas City, Mo., to make a complete report for a municipal electric light and central heating plant and electric distribution system. Estimated cost $450,000.

Mo., Farmington — State Eleemosyuary Bd., Jefferson City, awarded the contract for the construction of a 2 story ice and cold storage plant, including cork installation, doors, compressor, tank, condensor, etc. E. E. Harper, 3031 Park Ave., Kansas City, is engineer.

Mo., Hartville — The City will soon receive bids on equipment for hydro electric plant, including 42 kva., water wheel, alternator, 25 hp. oil engine, etc. Alexander Engineer Co., 517 Woodruff Bldg., Springfield, is engineer.

Mo., Poplar Bluff — W. H. Meredith representing a local syndicate, is having preliminary surveys made for a dam to check waters of Black River and also plans the construction of a hydro electric power plant, estimated cost $4,000,000. R. I. Randolph, 38 South Dearborn St., Chicago, Ill., is engineer.

Mo., St. Joseph—M. K. Goetz Brewing Co., is having plans prepared for a 4 story addition to cold storage plant. E. R. Mein, is architect.

N. Y., Brooklyn—Ocean Albemarle Corp., c/o Shampan & Shampan, Architects and Engineers, 189 Montague St., will build a 6 story apartment house on Ocean Ave. near Albemarle Road, estimated cost $700,000.

N. Y., New York — A. Campagna, 200 West 72nd St., will build a 14 story apartment house at 5th Ave. and 93rd St., estimated cost $1,000,000. J. E. R. Carpenter, 598 Madison Ave., is engineer.

N. Y., New York — City Construction Corp., c/o G. F. Pelham, Architect and Engineer, 200 West 72nd St., is having plans prepared for the construction of a 15 story hotel at Morningside Drive and 119th St., estimated cost $1,000,000.

N. Y., New York—W. H. English, 120 Broadway, will soon receive bids for the construction of a 15 story office and loft buliding at Elm and Duane St., estimated cost $2,750,000. H. C. Severence, 36 West 44th St., is architect.

N. Y., New York — N. J. Hess, 17 East 42nd St., has completed plans for the construction of a 15 story apartment house at 56 East 65th St. J. E. R. Carpenter, 598 Madison Ave., is architect and engineer.

N. Y., New York — Murray Hill Office Bldg., I. Harby, Pres., 270 Madison Ave., awarded the contract for the construction of a 26 story office building at Madison Ave. and 40th St., estimated cost $6,000,000.

N. Y., New York—Newmark, Jacob & Newmark, 3410 Broadway, will soon receive bids for the construction of a 15 story hotel on Morningside Drive, estimated cost $1,500,000. G. F. Pelham, 200 West 72nd St., is architect.

N. Y., New York—A. A. Paterno, 2300 Broadway, will build a 15 story apartment house at Amsterdam Ave. and 75th St., estimated cost $1,300,000. R. Candela, 200 West 72nd St., is architect.

N. Y., New York — Savoy Hotel, L. M. Boomer, Pres., 767 5th Ave., has completed plans for the construction of a 37 story hotel at 5th Ave. and 59th St., estimated cost $17,000,000. McKim, Mead & White, 101 Park Ave., are architects. H. G. Balcom, 10 East 47th St., is engineer.

N. Y., New York — Wheelock, Harris, Vought & Co., 14 Wall St., will soon receive bids for the construction of a 15 story apartment house at 167 East 72nd St., estimated cost $1,500,000. Rouse & Goldstone, 512 5th Ave., are architects.

N. Y., Schenectady—General Electric Co. awarded the contract for the construction of two plant buildings, one 5 story and one 15 story, to the United Gas Improvement Construction Co., Broad and Arch Sts., Philadelphia, Pa.

N. C., Rocky Mount—The City awarded the contract for the construction of a 125 x 40 x 55 ft. power house to D. J. Rose & Son, Rocky Mount, $110,000.

O., Columbus — The Continental United Power Co., a new corporation, has acquired the Columbus Railway, Power and Light Co., by a purchase of a majority of the common stock. Included in the merger are the Continental Gas and Electric Co., The United Light and Power Co., The Kansas City Power and Light Co., The Lincoln Gas and Electric Co., etc. C. S. Eaton, chairman of the board, F. T. Huslwit, Chicago, president. Columbus is to be made a center for the distribution of electric power, and the new plant of the Columbus Railway, Power and Light Co., 10 miles south of here, which was originally planned with a 50,000 kw. capacity, will be doubled and equipment to furnish 100,000 kw. will be installed.

O., Youngstown — Knights of Pythias, plans the construction of a 10 story hotel at Front and Champion Sts., estimated cost $1,000,000.

Okla., Braman—The City voted $25,000 bonds for a new water works system, including well, pump, tank, tower, valves, hydrants, etc. F. B. King, Grain Exchange, Oklahoma City, is engineer.

Pa., Philadelphia—Quartermaster Depot, 21st and Oregon Sts., will soon award contract for the construction of a 1 story, 53 x 42 ft. boiler house, including equipment.

Pa., Williamsport — Williamsport Hospital, H. Mosser, Chr. of the Bd. of Comn., 528 West 4th St., awarded the contract for the construction of a 7 story hospital on Rural Ave. and Spruce St.

S. C., Ehrhardt—Bids will be received until Nov. 5 at the office of the town clerk for a complete waterworks system, including pumping machinery, etc. Ryan Engineering Co., Arcade Bldg., Columbia, is engineer.

Tex., Crowell—R. W. Porter, Blackwell, Okla., awarded the contract for the construction of an electric power and ice plant, estimated to cost, $100,000.

Tex., Dilley — The City, R. Busley, Mayor, will soon receive bids for the construction of a pumping plant, tank and tower, also electric generator and ice plant, estimated cost $60,000. T. Bartlett, Calcasieu Bldg., San Antonio, is engineer.

Tex., Lubbock—The Bd. of Regents of Texas Technological College in office of A. G. Carter, Chr., Fort Worth, will receive bids until Oct. 28 for the construction of a power plant and equipment, including tunnels for steam and water lines. Staats & Hedrick, Fort Worth, are architects.

Wash., Anacortes—The City received bids and will soon award the contract for the construction of a filtration plant to treat 1,000 g.p.m., pumping station, pump and motor to deliver 1,000 g.p.m. into Whistle Lake from Lake Campbell, also 1400 ft. tunnel, estimated cost $150,000. W. B. Short, is engineer.

Wash., Seattle—The City Council and E. J. Brown, Mayor, have been unable to agree on the next step in the Skagit hydro-electric development and have instructed J. D. Blackwell, City Engineer, J. D. Ross, Superintendent of the lighting department, C. F. Uhden, Engineer of the Skagit project, to prepare a complete report covering all phases of the proposed development. C. F. Uhden, Engineer, recommends the construction of a masonry dam at Gorge Creek, which would raise the water in the Skagit River at the tunnel intake and increase the horsepower of the Gorge plant from 25,000 hp. for each of the two generators at high water season to 37,000 hp., estimated cost $4,000,000. A counter plan proposed by certain councilmen provides construction of a dam at Ruby Creek, 10 miles above the Gorge plant, as a means of increasing storage capacity of water to assure uniform horsepower the year around, estimated cost $8,500,000.

Wis., Madison—L. A. Smith, Supt., will soon award the contract for deep well pump and equipment in connection with new sewage disposal plant, estimated cost $6,000. E. E. Parker, City Hall, is engineer.

Wis., Milwaukee — Biltmore Grande Realty Co., c/o Rosman & Wierdsma, Architects, 490 Broadway, awarded the contract for the construction of a 4 story apartment house on Grande Ave., estimated cost $650,000.

Wis., Plymouth—Plymouth Refrigerating Co., E. J. Larson, Mgr., plans to purchase an ice making machine and refrigeration equipment.

N. S., Dartmouth — The City, Mayor Mosher, plans a chlorine gas plant, including motors and 3 pumps.

Ont., Grimsby — Hydro Electric Power Commission of Ontario, 190 University Ave., Toronto, is having plans prepared for a hydro electric system, including substation, equipment, switches, transformers, etc. Estimated cost $60,000. F. A. Gaky is engineer.